BLUE TECHNOLOGIES: USE OF NEW MARITIME TECHNOLOGIES TO IMPROVE EFFICIENCY AND MISSION PERFORMANCE

(115–44)

HEARING

BEFORE THE

SUBCOMMITTEE ON
COAST GUARD AND MARITIME TRANSPORTATION

OF THE

COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

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U.S. House of Representatives
Washington, DC 20515

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May 4, 2018

SUMMARY OF SUBJECT MATTER

TO: Members, Subcommittee on Coast Guard and Maritime Transportation
FROM: Staff, Subcommittee on Coast Guard and Maritime Transportation
RE: Hearing on "Blue Technologies: Use of New Maritime Technologies to Improve Efficiency and Mission Performance"

PURPOSE

The Subcommittee on Coast Guard and Maritime Transportation will hold a hearing on Tuesday, May 8, 2018, at 10:00 a.m., in 2167 Rayburn House Office Building to examine emerging maritime technologies. The Subcommittee will explore how such technologies could improve U.S. Coast Guard mission performance and enhance the safety and efficiency of maritime transportation. The Subcommittee will hear from the Coast Guard, representatives of industry, and academia.

BACKGROUND

The Coast Guard performs 11 official statutory missions including search and rescue, aids to navigation, law enforcement, and interdiction of illegal drugs. These missions have direct and significant impacts on commerce, property, and life in the United States. In 2017, the Coast Guard rescued or assisted nearly 12,000 people in response to the aftermath of hurricanes Harvey, Irma, and Maria.[1] The Coast Guard's missions not only support disaster relief, but are also essential to supporting the U.S. economy through its regulation, oversight, and enforcement of the U.S. Maritime Transportation System (MTS). The MTS remains is integral to the country's commerce, carrying 73.5 percent by weight and 46.6 percent by value of U.S. international merchandise.[2] In 2017 as a specific example, the Coast Guard's domestic

[1] USCG. FY2019 Budget Overview. https://www.uscg.mil/Portals/0/documents/budget/2019%20BIB_FINALw.pdf
[2] U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration. 2013 Freight Facts and Figures.
http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/13factsfigures/index.htm
(as of August 2014).

icebreakers conducted more than 5,300 hours of icebreaking to facilitate the movement of $1.5 billion of cargoes through ice-impeded waters of the Great Lakes and Eastern Seaboard.[3]

Maritime Domain Awareness (MDA), which is the effective understanding of the global maritime domain that could impact the security, safety, economy, or environment of the United States, is an important component critical to the Coast Guard's mission performance. As one of the military sea services, the Coast Guard gathers and distributes MDA information to other governmental and non-governmental partner agencies as it conducts each of the 11 official missions within a multi-layered security framework.

Congress continues to be interested in the Coast Guard's successful adoption and integration of new and emerging technologies. In the 115th Congress, versions of the *Coast Guard Authorization Act of 2017 introduced in the House* (H.R. 2518) and in the Senate (S. 1129) included a section requiring the Coast Guard to enter into an arrangement with the National Academy of Sciences (Academy). This arrangement would allow the Academy to prepare an assessment of existing and emerging unmanned technologies that could be used by the Coast Guard. The assessment will analyze how the use of new and emerging MDA technologies can assist the Coast Guard to carry out its missions at lower costs, expand the scope and range of the Coast Guard's MDA, use its personnel and assets more efficiently, and identify adjustments in any Coast Guard policies, procedures, and protocols to incorporate these new systems and technologies.

Blue Technologies

"Blue technology" is a term that describes a wide swath of technologies and systems that support, sustain, and integrate the U.S. and global ocean economy. Accordingly, systems and technologies such as autonomous vehicles, sensors (both remote and in situ), ocean observation platforms, and hydrographic services, among many others fall under the term. The integration of advanced blue technologies could improve operational efficiencies and the Coast Guard's mission performance, as well as MDA. Emerging maritime technologies may contribute to enhanced operational flexibility, improved understanding of the maritime environment, and optimal deployment and use of conventional Coast Guard assets (e.g., cutters, aircraft, small boats, etc.).

Search and Rescue

Rescue 21 is the Coast Guard's advanced command, control and direction-finding communications system that can locate distressed mariners at sea and on navigable rivers using Very High Frequency (VHF) radio transmissions. The system identifies the location of callers in distress through a line of bearing from the source of VHF radio transmissions to a radio tower, thereby significantly reducing search time. This direction-finding capability is a significant improvement over the legacy National Distress and Response System (NDRS), especially for mariners who may not be able to provide accurate positions. However, Rescue 21 relies solely on VHF radio transmissions, which is likely less prevalent than cell phones, particularly for mariners on smaller commercial

[3] USCG. FY2019 Budget Overview. https://www.uscg.mil/Portals/0/documents/budget/2019%20BIB_FINALw.pdf

and recreational vessels. The Coast Guard has an ongoing project assessing the use of cell phone technology to locate distressed mariners in mayday and search and rescue scenarios.[4] This project is scheduled to be completed in March 2019.

Integrated Communications

Efficient and reliable communications between Coast Guard shore-side facilities, ships, small boats, and aircraft are critical to MDA and Coast Guard mission performance. The Coast Guard is currently recapitalizing its offshore assets with an integrated communications platform. The Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) acquisition program acquires and integrates electronic sensors and computer networking, data processing and information-sharing equipment, to better enable Coast Guard Service members to perform mission tasks, develop situational awareness and improve coordination with U.S. agencies and allied nations. The C4ISR program also provides command and control equipment that enables cutter crews to navigate, maneuver, target and fire weapons; collect and analyze sensor data; and perform other tasks to support ship operations. The ability of all Coast Guard assets to successfully communicate with one another will assist the Coast Guard in conducting missions in a more efficient and cost-effective manner.

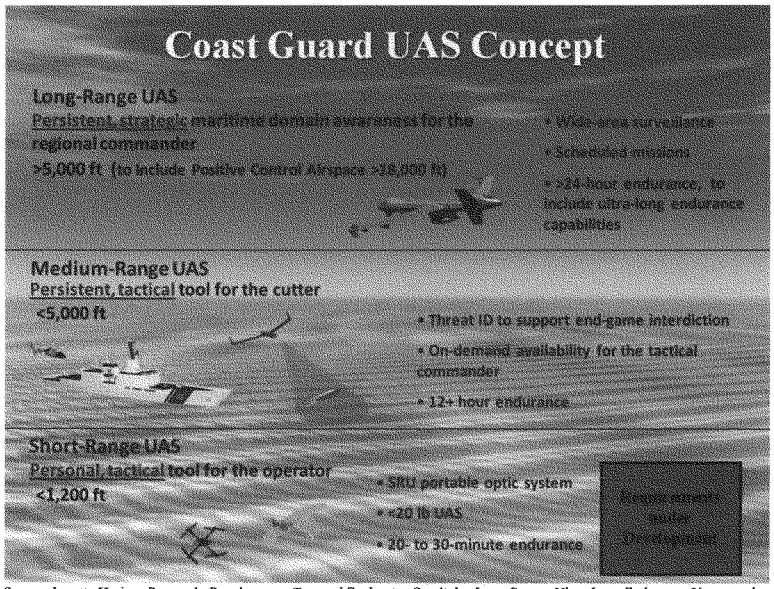
Unmanned Systems

Unmanned Maritime Systems (UMS), commonly described as autonomous and radio controlled Unmanned Surface Vehicles (USVs), and Unmanned Underwater Vehicles (UUVs), operate in surface or subsurface aquatic environments with the potential to increase MDA and support Coast Guard missions. Recent developments in radar and sensor technologies, power generation, transfer and storage, as well as delivery and recovery methods have led to a tipping point where investment in UMS could potentially provide a significant enhancement to Coast Guard operational capability. In partnership with other federal agencies, the Coast Guard has an ongoing project assessing UMS for Coast Guard missions, including understanding the scope of available platforms and evaluating the needs for full-scale application.[5] This project is scheduled to be completed in July 2018.

In the above-surface domain, there is an ongoing Coast Guard program to install small Unmanned Aircraft Systems (UAS) on National Security Cutters (NSC) in order to maximize NSC at-sea mission performance. This program was funded at $6 million in fiscal year (FY) 2017 and $500,000 in FY 2018, and the FY 2019 President's budget requested $6 million. Additionally, the Coast Guard has another ongoing project, in collaboration with Customs and Border Protection and the Department of Homeland Security, exploring the use of land-based, long-range and ultra-long endurance UAS, which could provide multiple days of surveillance while employing advanced optics,

[4] USCG Acquisition Directorate. Research, Development, Test & Evaluation. *FY18 RDT&E Project Portfolio.* March 2018. Project #1108.
[5] USCG Acquisition Directorate. Research, Development, Test & Evaluation. FY18 RDT&E Project Portfolio. March 2018. Project #7808.

wide-area surface surveillance, and detection technologies[6]. This program was funded at $18 million in FY 2017. H.R. 2518 includes authority for the Coast Guard to establish a land-based unmanned aircraft system program that would be under the control of the Commandant of the Coast Guard. H.R. 2518 passed the House on July 20, 2017 as Division E in *the Department of Homeland Security Authorization Act* (H.R. 2825) and the provisions of H.R. 2518 are included in S. 1129, which is awaiting Senate Floor action.



Source: Loretta Haring. *Research, Development, Test and Evaluation Spotlight: Long-Range, Ultra-Long Endurance Unmanned Aircraft System.* Coast Guard Compass. Jan 9, 2018.

As UAS become more widely available and affordable, concerns are being raised regarding the risk that unauthorized UAS may jeopardize Coast Guard operations. In March 2018, the Coast Guard MH-65 Dolphin helicopter crew from Air Station Port Angeles in Washington state was conducting training exercises near the airport when the crew maneuvered to miss a drone at an estimated distance of 50 feet.[7] The drone had not been authorized by the Federal Aviation Administration to fly within the five-mile radius of the airport. This incident highlights a need to better manage increased interactions from unauthorized UAS activities with Coast Guard surface and air assets. The Coast Guard has an ongoing counter-UAS project evaluating methods to search, detect, mitigate, and defeat illicit, illegal or threatening use of unmanned aircraft systems in a

[6] Loretta Haring. *Research, Development, Test and Evaluation Spotlight: Long-Range, Ultra-Long Endurance Unmanned Aircraft System.* Coast Guard Compass. Jan 9, 2018.
[7] USCG news release, Mar 20, 2018. https://content.govdelivery.com/accounts/USDHSCG/bulletins/1e3927a

maritime environment.[8] This project is scheduled to be completed in December 2020. S.1129 includes a section that would provide the Coast Guard with authority to address and mitigate threats posed by unmanned aircraft to the safety and security of a Coast Guard vessel or aircraft or any vessel or aircraft the Coast Guard is assisting or escorting.

Automatic Identification System (AIS)

AIS is important for both safe navigation and MDA aspects of the Coast Guard's missions. AIS is a VHF-based, short-range communication system that provides a common platform for vessels to electronically exchange relevant vessel data (e.g., vessel identification number, vessel type, position, course, and speed) with other nearby vessels and shore-based AIS receivers. AIS data is overlaid on electronic charts to provide vessel operators with near real-time information on positions, courses, and speeds of other vessels. Several private companies have developed enhanced AIS systems that leverage navigation data from satellite and other sources and integrate it into a single common operational picture that can be viewed on several platforms including smart phones.

Navigation Services

The Coast Guard maintains a system of over 47,000 federally owned, lighted and unlighted, buoys, beacons, and other aids-to-navigation (ATON) that mark 25,000 miles of waterways and navigable coastal waters. In recent years, the Coast Guard has augmented its physical ATONs with electronic or virtual ATONs, using AIS technology.[9] Electronic ATONs may enhance MDA and form an improved view of maritime traffic within or near U.S. and territorial waters. Use of electronic ATONs have been limited in the U.S. Arctic due to the lack of major ports and minimal maritime traffic. To address navigation safety and risks in the Arctic, the Coast Guard has an ongoing project examining a next generation Arctic Navigation Safety Information System including a near shore system and extended range AIS.[10]

Maritime Boundaries of Exclusion

To conduct port security or environmental remediation, the Coast Guard may need to temporarily exclude unauthorized users from a maritime location. For example, during the 2016 Democratic and Republican National Conventions, the Coast Guard issued temporary security zones in the waters near the events, where unauthorized vessels were not permitted to enter without permission from the Captain of the Port.[11] To communicate the boundaries of exclusion to maritime users, the Coast Guard may use a combination of physical markers and manned patrols. There is an ongoing Coast Guard project to improve ways to mark, communicate, and patrol the boundaries of a maritime

[8] USCG Acquisition Directorate. Research, Development, Test & Evaluation. *FY18 RDT&E Project Portfolio.* March 2018. Project #7812.
[9] USCG Report to Congress. May 4, 2016. Electronic Aids to Navigation.
[10] USCG Acquisition Directorate. Research, Development, Test & Evaluation. FY18 RDT&E Project Portfolio. March 2018. Project #6211.
[11] 81 Federal Register 48331; 81 Federal Register 41811

area of exclusion, without a dependence on manned Coast Guard patrols.[12] Using novel technology to successfully fulfill missions while decreasing reliance on manned patrols enhances Coast Guard operational flexibility.

Data Analytics

Data analytics improves decision-making through the use of modeling and simulation based on collected data. The Coast Guard has an ongoing project to estimate vessel violation probabilities in marine vessel inspections. This project identifies factors that influence a vessel's probability of having a violation and develops tools to optimize detection with limited inspection resources.[13] The use of data analytics within the Coast Guard advances optimal deployment of assets and personnel.

[12] USCG Acquisition Directorate. Research, Development, Test & Evaluation. *FY18 RDT&E Project Portfolio*. March 2018. Project #5921.
[13] USCG Acquisition Directorate. Research, Development, Test & Evaluation. *FY18 RDT&E Project Portfolio*. March 2018. Projects #7532

WITNESS LIST

Panel I

Rear Admiral Michael J. Haycock
Assistant Commandant for Acquisition and Chief Acquisition Officer
United States Coast Guard

Panel II

Mr. Eric J. Terrill, Ph.D.
Coastal Observing Research and Development Center
Scripps Institution of Oceanography

Mr. Michael B. Jones
President
The Maritime Alliance

Mr. Chris Coyle
Member
International Ocean Science and Technology Industry Association

Mr. Thomas S. Chance
Chief Executive Officer
Autonomous Surface Vehicles, LLC

Ms. Tuba Ozkan-Haller, Ph.D.
College of Earth, Ocean and Atmospheric Sciences
Oregon State University

Rear Admiral Jonathan W. White, USN, Ret.
President and Chief Executive Officer
Consortium for Ocean Leadership

BLUE TECHNOLOGIES: USE OF NEW MARITIME TECHNOLOGIES TO IMPROVE EFFICIENCY AND MISSION PERFORMANCE

TUESDAY, MAY 8, 2018

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:02 a.m., in room 2167, Rayburn House Office Building, Hon. Duncan Hunter (Chairman of the subcommittee) presiding.

Mr. HUNTER. Good morning. The subcommittee will come to order.

Today the subcommittee will hear testimony on how emerging maritime technologies can improve the efficiency and performance by the Coast Guard.

The Coast Guard performs many important missions, from defense readiness and migrant and drug interdictions, to search and rescue operations and fisheries law enforcement. However, since 2010, annual administration requests for the Coast Guard have not been adequate for the Service to acquire new assets to perform its 11 missions at a rate that keeps up with those mission needs.

This subcommittee has urged the Coast Guard to strongly advocate for the resources it needs to acquire the assets necessary to conduct its missions. The National Security Cutter acquisition program has exceeded the program of record; the Fast Response Cutter acquisition program is getting close to completing the program of record; while the Offshore Patrol Cutter and polar icebreaker acquisition programs are only just beginning.

The reality of the Coast Guard's operational situation is that even with new assets, the Coast Guard has a big job to do. This subcommittee recognizes that technology can be a tool to fill any operational gaps in a cost-effective manner.

Unmanned systems, navigation technologies, and new cell phone technologies are all tools that the Coast Guard can use to improve their mission performance. These technologies can improve the Coast Guard's maritime domain awareness and help the Coast Guard more effectively target the use of expensive manned assets. The Coast Guard needs to use every tool out there.

The Coast Guard cannot accomplish all their missions by simply putting their service men and women on cutters, helicopters, and planes. The Service needs to be smart and strategic about where

to place its assets and use its personnel. This is where data and technology can help.

For example, Indonesia has partnered with Google to catch illegal fishing in realtime. Google co-founded Global Fishing Watch, an online mapping platform. Fishermen, or pirates, turn off their tracking system when they are illegally fishing, but Google's mapping platform is able to use machine learning to study vessel movement patterns to locate them.

This was all done using Government-owned vessel monitoring system data in the mapping platform and adding new raw satellite imagery to produce a detailed footprint of fishing activities, revealing 5,000 previously invisible boats, and allowing Indonesian law enforcement to address illegal fishing in its waters.

This subcommittee will keep pushing the Coast Guard to be innovative. The types of technologies we will discuss today can help the Coast Guard strategically and more effectively use its assets.

There is no replacement for trained and capable servicemembers, but if the Coast Guard makes better use of technology, this can make servicemembers' jobs more effective and safer.

I held a roundtable in San Diego in February and met with a variety of companies that are working on new maritime technologies. I know we have some of those panel members with us today as well as other experts. I look forward to learning about the current technologies that exist right now and the technologies that the Coast Guard is using and working on to use in the future.

Lastly, I want to say when we are at the Joint Harbor Operations Center there in San Diego where the Coast Guard operates out of, now you have a Harbor Police desk inside the Coast Guard operations center where you can see the entire Coronado Bay, all of the San Diego Bay, all of the Naval Institution, everything. You can see around the entire area in realtime.

And the Coast Guard cameras are operated by National Guardsmen. When the two National Guardsmen who were watching the Coast Guard cameras, and this was about 2 months ago, left to go to Ukraine, I think, or Georgia to help train people, those two seats were empty. The Coast Guard did not have anybody there.

So even with the technology and the cameras and the assets to be able to look at the entire San Diego Bay, they were saying, "Well, that is great, but we cannot do it because we lack two people." So that was not a technology issue. That was a manning problem, which they are fixing now.

But it was great to see at least that technology being in place and tied in with the Harbor Police and everybody else in the San Diego Bay region.

So I would like to thank our witnesses for being here today and I look forward to hearing their thoughts on these issues.

And I yield to Ranking Member Garamendi.

Mr. GARAMENDI. Mr. Chairman, thank you so very much.

I appreciate the opportunity to delve into these blue technologies and discuss their potential to transform how we envision both the maritime infrastructure and emerging information systems and the technologies that drive advancements in science and industry.

The hearing could not come soon enough. Over the past decade, countries around the world, especially China and the European

Union, have turned their attention to their coasts and oceans to investigate the potential of maritime-related industries, ocean resources as a major source of new jobs and economic growth.

The U.S. would be well advised not to ignore this push by other nations to expand their economic opportunities in the maritime economy. If we do ignore it, we risk falling behind the development, testing, and deployment of the new blue technologies driven by marine data that is easily accessible, interoperable, and we squander future opportunities to develop new products, services, and applications to strengthen and diversify our maritime economy.

Fortunately, many of the folks here have not been sitting idly on the sidelines. In fact, each of our witnesses here this morning can attest to numerous achievements thus far and examples of innovation.

For instance, a leading edge, very high frequency-frequency modulation—VHF–FM—communication systems, known as Rescue 21, is the Coast Guard's new advanced command, control, and direction-finding communications system that has enabled the Coast Guard to execute its search and rescue missions with far greater agility and efficiency.

Another example is the physical oceanographic real-time system, or PORTS [Physical Oceanographic Real-time System], a decision support tool developed by the National Oceanic and Atmospheric Administration that improves the safety and efficiency of the maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and geospatial information.

I am sure we will hear from witnesses about these and other activities.

A recent article in the Maritime Executive focused on Russian activities in the Baltic and eastern Mediterranean to jam and disrupt GPS systems that vessels rely upon, and we will explore some of that with our witnesses.

Considering that many blue technology systems rely on satellite telemetry and precision signals for timing, navigation, and communication, what would happen to these new assets, whether they are unmanned gliders or maritime electronic navigational systems, if their GPS signals were disrupted either intentionally or unintentionally.

Presently, the U.S. has no active domestic backup timing and navigational system should GPS go down, and I think you have heard me speak on this before. So I will not go on further, except to say that former Secretary of Defense Ash Carter said it correctly. GPS is a single point of failure. So a piece of work we need to do.

A fascinating hearing. We are going to hear from others. There is so much that we need to do in this domain and in this area so that the blue technology systems are American and used by our mariners and our military.

So with that in mind, let me conclude by welcoming our witnesses. I look forward to hearing from you, and I hope to engage all of you in questions.

I yield back my time. Thank you, Mr. Chairman.

Mr. HUNTER. I thank the gentleman from California.

And this is a great panel, which we have one person——

Mr. DEFAZIO. Can I go?

Mr. HUNTER. Oh, Mr. DeFazio is recognized for an opening statement.

Mr. DEFAZIO. It is early, Duncan. Thank you.

Thanks very much for having this hearing. You know, this is an area where the Government should be investing a significant amount more money in acquiring new technologies, not just for the Coast Guard, but for those who research the oceans.

Seventy percent of Earth's surface: ocean. We have explored thoroughly about 10 percent of it, and 50 to 80 percent of the life on Earth exists in the oceans.

You know, we are a maritime Nation. It is incredibly critical to our future that we not be left mired in the 20th century when other nations are employing 21st-century technology to better understand our oceans and in some cases exploit our oceans, in some cases exploit to the point of being unsustainable. We need to better understand the majority of Earth's surface.

And I really want to thank the chairman for holding the hearing, and I want to acknowledge Dr. Tuba Ozkan-Haller. She is a professor of civil and construction engineering at Oregon State University. She is the associate dean of the College of Earth, Ocean, and Atmospheric Sciences.

We had a little brief discussion beforehand. I know that for one thing we have underfunded the deep-ocean buoys. I have been working both for earthquake detection, remote sensing out near where the tectonic plates meet off the northern California-southern Oregon coast.

And I have also been very concerned about the lack of capability of just doing more mundane things like detecting wave heights and directions and that for coastal shipping safety and mariners, and others, and also so we can better understand these oceans if we want to deploy or hope to deploy wave generation systems or wind generation systems on the ocean's surface. We need to know a lot more about what is going on out there.

So I think this is critical for the Coast Guard, critical for the United States of America, critical for the future of our economy.

With that, I thank the chairman and yield back the balance of my time.

Mr. HUNTER. I thank the ranking member of the full committee for being here. It is always a great honor to have him and shine some light on what we are doing here as well.

I just want to say when I got into this about 6 years ago when I became the subcommittee chairman, I had gone to somewhere in Silicon Valley and saw a thing that the guy that invented Java was working on, floating surfboards that can sense oil in the water and has sensors on it and can drive themselves infinitely, for a long time.

So I came back, and it was one of my first subcommittee hearings here, and I asked the Coast Guard. We went through all of the language in Coast Guard regulations to see what they would classify that as, and it came back as "floating debris." That is what the Coast Guard lawyers would call it, the guy who invented Java's

surfboard that can sense stuff. It was classified as "floating debris." That was 6 years ago.

I think things have changed. So if you could tell us how things have changed, it would be great.

Rear Admiral Michael Haycock, Assistant Commandant for Acquisition and Chief Acquisition Officer for the United States Coast Guard, you are recognized.

Thank you for being here.

TESTIMONY OF REAR ADMIRAL MICHAEL J. HAYCOCK, ASSISTANT COMMANDANT FOR ACQUISITION AND CHIEF ACQUISITION OFFICER, U.S. COAST GUARD

Admiral HAYCOCK. Chairman Hunter, Ranking Member Garamendi, distinguished members of the subcommittee, Congressman DeFazio, thank you for the opportunity to speak about the Coast Guard's ongoing efforts to pursue new technologies and solutions that have great potential to enhance our mission success.

I thank you for your oversight and your continued support of our Service, and I ask that my full written testimony be included as part of the official record.

As the Assistant Commandant——

Mr. HUNTER. Do you mind pulling up the microphone a little bit closer to you, too? Thank you.

Admiral HAYCOCK. Is this better?

As the Assistant Commandant for Acquisition, I have several opportunities to testify before this body on the Coast Guard's programs, to revitalize our aging fleet of cutters and aircraft, boats and support systems. And with the support of the Congress, and especially this subcommittee, we are making real progress towards delivering the assets and the capabilities that our men and women in the field need to execute the missions for the American people.

Our continued operational success will require a broad portfolio of complementary programs and activities that are built upon a foundation of innovation, integration, and strategic vision.

One such program is the Coast Guard's Office of Research, Development, Test and Evaluation, which supports research and innovation across the entire span of the Coast Guard's missions. The Coast Guard RDT&E project portfolio is closely aligned with the mission needs and the priorities that are identified by our operational community.

Because the program is relatively modest, we are constantly looking at ways to best leverage partnerships with DHS [Department of Homeland Security] and DoD [Department of Defense] research entities, national laboratories, academia, and industry to best support the Coast Guard's needs.

One example of leveraging partnerships is our Research and Development Center's effort with the DHS Science and Technology Directorate to form the DHS/Coast Guard Science and Technology Innovation Center, also known as the STIC. This joint Coast Guard and DHS team is focused on rapidly transitioning innovative technologies into the hands of our operational community.

We are also working with DHS Centers of Excellence on projects related to maritime cybersecurity and in the Arctic as well.

We are also at the table with the Defense Advanced Research Projects Agency, also known as DARPA, to look at counter-UAS [unmanned aerial systems]. We have conducted in situ burning testing at the Joint Maritime Test Facility in Mobile, Alabama, through partnerships with entities such as the Bureau of Safety and Environmental Enforcement and the Naval Research Laboratory.

We also collaborate with industry through numerous cooperative research and development agreements, also known as CRADAs. These agreements are mutually beneficial in providing industry partners with access to real world requirements while keeping the Coast Guard abreast of the latest developments in technology.

We have formalized these cooperative R&D agreements with industry leaders such as Mercury Marine, Lockheed Martin, Conoco Phillips, and several others, and right now we are looking at a number of ways to increase the number of partnerships with smaller innovative technology companies as well.

This year marks the RDT&E program's 50th anniversary, and throughout the program's history, it has delivered products and capabilities that are vital to carrying out or Coast Guard missions. Projects have been driven by events such as *Exxon Valdez*, hurricane responses, *Deepwater Horizon*, and the recent sinking of the SS *El Faro*.

We have led research in oil spill mitigation, development of electronic navigation, and other research areas important to mariner safety and commerce. Last year was one of our busiest years to date. When the Coast Guard swung into action as Hurricane Harvey swept through the gulf coast, the RDT&E program was there.

We used our innovative crowd sourcing platform to collect real-time lessons learned from responders on scene. The responders told us stories about sending 50 small rescue boats and 28 helicopters into the storm with limited ability to track the rescuers or the assets that they were in.

The Research and Development Center in New London, Connecticut, immediately sprung into action and began prototyping small, affordable, off-the-shelf tracking devices that could provide our operation commanders with options for greater situational awareness even under the most challenging conditions. The program is nimble, and it is able to respond quickly.

In addition to meeting emergent needs, the R&D program is working to help strategically position the Coast Guard for the future. With the ever-increasing level of automation within the Maritime Transportation System, we are working to stay ahead on cybersecurity challenges and threats. The program is developing improvements to communications capability and domain awareness in the Arctic, and we are collectively excited about the potential improved mission effectiveness made possible by machine learning and artificial intelligence and augmented reality and other emergent technologies.

The program is looking at potential Coast Guard uses for autonomous and semi-autonomous systems from the seafloor to space, as directed by Congress.

Technology changes at a very rapid pace, and the researchers and the engineers and innovators in our RDT&E program are

poised to find efficiencies, reduce risk, and explore technologies to optimize mission performance.

As the Service moves in new directions, research and development will be increasingly vital to provide this knowledge for the Coast Guard.

I thank you for the opportunity to testify before you today, and I look forward to your questions.

Mr. HUNTER. Thank you, Admiral. I appreciate it.

I want to bring up a couple systems and a couple example of things that are not crazy. They are not seafloor to space. They are not big disruptors, but something like the long-range acoustic device, the LRAD, which when I was in San Diego, they had a couple on Coast Guard ships now. I think one or two little cutters have been using them down in Florida.

The Navy has had these for over 5 years on every single Navy ship, and for everybody that is watching or listening, it is a speaker, and you are really loud when you talk on it. That is what it is. It is called long-range acoustic device. You can hail people at like 100 meters away, and they can hear you in the pilothouse of the boat when you are yelling at them.

I thought it was amazing that the Coast Guard are the people who yell at people to get out of an area don't have that, and the people who shoot at people do have that. Literally every Navy ship has them, and the Coast Guard is still testing as of 2 months ago, after 5 years of Navy use.

That is unacceptable. There is no reason to be testing something that the Navy has been using for 5 years on literally every single Navy surface ship that is now on one Coast Guard ship.

Another example are Predators. You talk about autonomous vehicles, remotely piloted vehicles, unmanned vehicles, artificial intelligence vehicles. You don't have them. Everybody else has been using them but you.

You are the smallest force. You have the fewest number of people. You get the least amount of money every year, and you are the slowest to adopt technologies that can leverage your undermanned Service in accomplishing your 11 missions. But you are the slowest to adapt those technologies, and that is why we are having this hearing today.

So I guess the first question I have is a number of unmanned marine systems are being developed that have the ability to act as a force multiplier. We are talking about any kind of UAV [unmanned aerial vehicle] that has a maritime sensor, and that is quite a few now, and you can slap different maritime sensors on any kind of UAV, big or small.

Such systems have long endurance. It can detect illicit vessel traffic, and some can even act as a visual deterrence, and who knows yet what we can have them do when it comes to turning off motors, doing things like that where they can zap these fast boats if there is not a marine layer or something like that where they can see.

So has the Coast Guard explored the use of these systems to improve demand awareness in transit zones?

And what role do you foresee in the future?

And let us go back to the previous Commandant. Admiral Zukunft said that he did not want Predators or UAVs off the coast of San Diego or Florida. He wanted them flying over South and Central America so they could get good keys and cues on the bad guys coming north, not necessarily when the boat is going 70 miles an hour in the ocean off of Orange County.

So that was what he had talked about and kind of his vision, and I would like to hear now how that is going to play into what you think and what the new Commandant thinks of doing that, or whether he wants to see UAVs off the coast of Orange County.

Admiral HAYCOCK. Thank you.

The unmanned aviation systems come in a variety of capabilities and sizes. So the one you are talking about or most recently were talking about were the semi-long range and ultra-long endurance UAVs.

And thanks to Congress and this subcommittee, we received money in fiscal year 2017 to actually explore that and actually do a demonstration of that.

We have worked with folks at DHS, in particular, the PEO [Program Executive Office] for UAV systems at DHS, and Customs and Border Protection as well, and we have been working together for the last year or so to put that program into place, and I am excited to announce that we actually issued the request for proposals last week to actually get that demonstration in place to see how that technology can be used in the Coast Guard for long range.

In kind of the middle-range area, we make great strides on a small UAS that we can deploy on our ships. So we actually have kind of a prototype system over the last several years with Coast Guard cutter *Stratton*. So we deployed a UAS onboard for three or four deployments, and that UAS has provided great capabilities, and our crews love them. They provide maritime domain awareness on sight.

Mr. HUNTER. What is it? What UAS system or what UAS?

Admiral HAYCOCK. It is the Insitu ScanEagle, sir.

Mr. HUNTER. ScanEagle, got you.

Admiral HAYCOCK. Yes. So that is a catapult-launched asset that we launch off the flight deck. We launch it up in the air. It provides intelligence, surveillance, reconnaissance capabilities.

We have had to develop policy to make that happen, but it has been working phenomenally. It has contributed to drug busts in theater, to a number of these things, and the crew loves it.

And I am excited to announce that probably in about 2 weeks we will be issuing or we will actually be awarding a contract to put that capability on eight NSCs for the next 5 to 8 years.

And that is technology that our fleet loves, and they are going to be really excited to get that deployed.

Finally, in kind of the short range, kind of the hand-launched area, our Assistant Commandant for Capabilities has authorized our small boat field units to go out and procure some of the smaller UAS to test them, find out what sort of utility they have in the field, and then we will use those lessons learned to go out and create a policy and then go after a kind of a standard asset.

Mr. HUNTER. The last thing I would recommend, you have had Special Forces, Army and Navy and Marine Corps, and the Navy

just in general, on small boats launching UAS for a decade now, for about 10 years. So they are about 10 years ahead of you, the non-sea services are already ahead of you, including Army and Marine Corps sea service.

I think you have got some catching up to do. Can you tell me really quick the difference between launching an unmanned vehicle off of a Navy ship compared to launching an unmanned vehicle off of a Coast Guard ship?

Do the ships float differently or what is the difference?

Admiral HAYCOCK. So the primary difference between the way we use our ship-launched UAS and probably the Navy is we have slightly different mission sets, and so we need our assets to provide ISR [intelligence, surveillance, and reconnaissance] for long periods of time. So we are looking for assets that can be up for 12 or more hours off the ship to kind of increase our awareness of what is going on around the actual ship itself. It increases our visibility.

We have to contend with weather. We typically find ourselves going——

Mr. HUNTER. Wait. The question is: What are the differences?

So the Navy contends with weather. They contend with different ship sizes and different things, too. So when you are in the ocean and a Navy ship is in the ocean. It is the same size ship. What is the difference between them being able to launch UAS and having been doing so for years and the Coast Guard?

I mean, what is the technical difference of launching a UAS off a Coast Guard ship in the same ocean that a Navy ship is sitting?

They are the same size ships. They are in the same ocean. What is the difference?

Admiral HAYCOCK. There are no technical differences between the two assets.

Mr. HUNTER. Should there be a Navy-Coast Guard joint program office for unmanned systems as well, like the icebreaker so we can get everybody on the same page?

Because the Navy has more money, as we all know, more people, more testing, the ability to do this because they have been doing it for longer. They are not jumping through hoops anymore.

I mean it is a great system to probably copy in your own way is what I am saying.

Admiral HAYCOCK. As you know, our integrated program with the Navy on icebreakers has been a phenomenal endeavor so far. We have made great progress.

I don't know that we need that for the UAS because we have actually made phenomenal progress on this endeavor as it is so far. We are on the cusp of actually deploying that here on all of the NSCs. So I don't know that we need help at this point in time.

It might have been helpful if we had done it years back, but I think we are in a good place, sir.

Mr. HUNTER. But, again, you are talking about ScanEagle, which is extremely old technology with hopefully new sensors on it, but this is not groundbreaking, right?

It is a little bit late to the game, but better late than never.

Admiral HAYCOCK. Well, I don't know what system we will actually be deploying because we have not awarded that contract yet. The prototype was ScanEagle. We have not identified any major

issues with ScanEagle. That UAS has done phenomenal for us, and we are really excited about awarding the contract and getting this permanently on the ships.

Mr. HUNTER. Thank you.

I yield to the ranking member, Mr. Garamendi.

Mr. GARAMENDI. The chairman is working on a line of questioning that I think is really important here, and that is the adoption of new techniques and technology. And apparently the Coast Guard in its adoption process is slow to adopt, and the questions that I would like to get to really are the organizational structures that would retard the adoption of new technologies, new techniques, equipment, and so forth.

Let us start with the budget for the development, testing, and evaluation program. I think you are requesting like $17.2 million, which is 47 percent less. Why?

And if this particular budget or line item is critical in the adoption of new techniques, technologies, and equipment, why the reduction?

Or maybe this isn't where the problem lies. Could we just go into that for a few moments?

Admiral HAYCOCK. Our R&D budget has been fairly consistent over the years. I am wondering if you are talking about the 47 percent because of the $18 million plus-up for the long-range UAS.

You know, we have been operating at around $18 million for the last several years for the R&D budget, and that gets us where we need to go. It would obviously be better if we had more, but we find ways of getting around that by leveraging the other entities out there that have done some of this work.

One of the things we are trying to prevent ourselves doing is recreating the wheel, duplicating efforts done by others. And so one of the things we do is we partner with the national laboratories, the Naval Research Lab.

We just recently got into an agreement with the Air Force, the first of its kind, to leverage some of the stuff they are working with; you know, working with the DHS Science and Technology Directorate.

So we do these things to kind of augment that and make up for, you know——

Mr. GARAMENDI. Well, you know, all well and good. The notion of working with other agencies and using their knowledge and testing, excellent. How then does that get into the operations of the Coast Guard?

How do you transition that information?

I am looking at the organizational structure. There is something here that isn't working smoothly. Technologies are readily available, techniques, but the Coast Guard isn't adopting them.

As the chairman was driving into this, what is it in this organizational structure that is retarding the integration of these new systems into the Coast Guard's daily operations?

If it is not this RDT&E, apparently that is not important, and you are able to make up for the less money by utilizing other agencies. Then that information, that knowledge from other agencies has to find its way into the Coast Guard. How does it get there?

How is it acquired?

Admiral HAYCOCK. There are a number of ways we do this. One of the things we tried to do recently is we are trying to spur more innovation within the Service. So we have stood up an Innovation Council, which has senior leaders here at headquarters that are engaged in RDT&E efforts, to provide guidance and oversight.

We have created a crowd sourcing platform that has gotten great use over the last year or so, where we basically allow folks at all levels in the organization, from military, civilian, you know, young, new sailors all the way up to senior officers can all provide input on various topics that we put in the crowd sourcing platform. That allows us to get new ideas to go after.

The second thing we do is we use that information to create a portfolio of things we believe are the best return on investment for the Coast Guard.

Since I arrived in CG–9 last spring, one of the things I have asked the Research and Development Center to do is place a greater emphasis on the actual transition of the research and development efforts into products that the operational Coast Guard can use. So now our folks up there, when they do this, they also look at, OK, what is the next step in the process. How do we go about putting this into the operational user's hands in the Coast Guard?

Mr. GARAMENDI. Can you develop and deliver to the committee a portfolio, the word you used, of ideas, products, techniques, technologies that are currently being looked at by your organization?

Something is amiss here, the adoption and the openness to new ideas. Like how does an individual from—I don't know—say Scripps who has developed a great sensing device that could be used on one of your ships get to your office so that you can acquire that knowledge, that technique?

In other words, is your door open?

Admiral HAYCOCK. Yes, sir, the door is definitely open, and we are excited about opportunities to do this sort of thing.

Mr. GARAMENDI. There is a whole series of questions. I can go on for some time here about this. We sense that there is a slowness, a reticence within the Coast Guard to adopt new techniques, new technologies, new equipment. The chairman gave three different examples a moment ago.

What is it about the organization that is retarding the acquisition of these new systems?

Just for example, we know that the Offshore Patrol Cutters are someday going to get out there. In the meantime we have ancient equipment that is not terribly reliable. What are we doing in the intervening period to use these new systems, to understand the domain, the maritime domain?

Are we open to that? Are you open to that?

Admiral HAYCOCK. We are open to that.

Mr. GARAMENDI. And what are you doing in your openness?

Admiral HAYCOCK. Well, part of it is we need to know that it exists, and that is one of the key roles our Research and Development Center plays, is getting out there and finding out what sort of technology exists.

So the folks at the R&D Center are constantly on the prowl. They are out there visiting folks. They are doing research online. They are attending conventions. They are having meetings with

technology centers, things of that nature so that we are aware of those capabilities.

The next step, after you have been made aware of this, you have got to prioritize it and make sure you are using your resources for those things that bring the best value to the operator out in the field.

We have a process for that, and that process starts usually in the end of the summer, and we get input from the field, and then we later in the winter we actually bring people together. Usually we get an external look from the Naval Research Lab, S&T, the chief scientist for DHS. We will bring all of these senior folks into the room, and we will go through all of these projects in detail to determine which ones make the most sense for the Coast Guard to go after.

And then we put that portfolio together, and then that is the marching orders for the R&D Center, and they go out and they go after this.

Mr. GARAMENDI. Your title is Commandant for Acquisition and Chief Acquisition Officer, and I know this committee puts a lot of pressure on you for things like icebreakers and other major pieces of equipment. I think we are putting more pressure on you about these other systems, not the big ones, but all of the systems that make the icebreaker more effective, more efficient; the Offshore Patrol Cutters more effective, more efficient.

And these are not the big, flashy things, but these are UAS, other devices that expand the ability of the Coast Guard to carry out its many, many tasks.

And so just since you have such broad shoulders, in addition to the major acquisitions and the recapitalizations that are underway, these other things, my question really goes and my issue really goes to the organizational structure that provides the open door for these systems to be brought to the Coast Guard and then implemented along the way.

So I am going to drive at that. Right now I think I have taken much more time than I would otherwise have available, but the specific question: How could the Coast Guard improve its interactions with the blue technology industries and firms sufficient to keep the Coast Guard abreast of the latest development and innovations?

So this is an organizational question for which I will be driving, and I suspect the committee will drive, too.

So thank you very much for that. I yield back.

Mr. HUNTER. I thank the ranking member.

Mr. Graves from Louisiana is recognized.

Mr. GRAVES OF LOUISIANA. Admiral, thank you for being here.

I want to start out with something that is perhaps not in your column but affects the Coast Guard nonetheless. We recently had a boating accident off the coast of Louisiana where three folks were out there, and I have been on the phone with numerous Coast Guard men and women over the past several days, including the commander sitting behind you, and I do want to give a big shoutout to the Coast Guard for their efforts on that search and rescue. That is our mission.

I know you had a lot of assets out there. I know you were working very closely with the Louisiana Department of Wildlife and Fisheries, the Plaquemines Parish Sheriff's Office. Certainly all lives are important.

One of the gentlemen who was lost really had a transformational effect. My own town of Baton Rouge started a church after the Billy Graham crusade and saved a lot of lives in many, many ways.

So I just want to thank all of the men and women of the Coast Guard for their efforts overnight and countless hours and airplanes, helicopters and boats, assisting in that mission. Very, very important. So thank you.

Changing gears a little bit, can you talk a little bit? Your testimony makes reference to some of the research and development and perhaps advances that you have made in oil spill technology. You talk specifically about in situ burns at your facility in Alabama.

Can you talk about other advancements that the Coast Guard is involved in, but perhaps also collaboration with industry in the aftermath of *Deepwater Horizon*?

Admiral HAYCOCK. First, thank you for recognizing the efforts of the Coast Guard. The folks that go out there and do the rescues, they don't do it for the recognition, but they do appreciate the fact that people notice. They are just doing what they are trained to do, and we appreciate the support, and we appreciate the support of the committee, as well.

The Joint Maritime Test Facility down in Alabama is a great national asset. We partner with BSEE [Bureau of Safety and Environmental Enforcement] and Department of Energy and others to make best use of that.

Technology is changing all the time, and as we look at things like response to oil spills, we can use that facility to try different techniques to mitigate the oil spill. So that facility is up and running and we get great support on that, and we get a lot of collaboration with industry to make that happen.

We take our oil spill responsibilities very seriously, and one of the things we have recently done—I think the committee will be happy to know—is we have looked at things like how do you recover oil that is sinking in the water column. How do you detect it and go after it?

So we actually just completed a test recently here in that endeavor, looking at how do you best recover that. So we have got some great data from that. We are going to use that data to figure out what is the next step in that endeavor to improve our ability to mitigate oil spills.

Mr. GRAVES OF LOUISIANA. First, I just want to ask if you all could on the record or perhaps coming back and giving us a briefing on updates on some of the efforts by private industry to improve safety techniques because certainly you need to be working in collaboration with them.

I know that they have made substantial progress in new safety techniques and collection devices and other things, and I think it is important that the Coast Guard and industry are working very closely together.

Again, I have been briefed on a lot of technology they have developed, and it really is impressive.

In regard to the oil sinking, the only time I have really seen that happen is in the case of *Deepwater Horizon* when you all hit it with the dispersant below the surface. Otherwise I think the oil comes up. The only other instance is when it binds with the fine silts and sands and, therefore, changing the weight of it.

But I think there are a lot of lessons learned from *Deepwater Horizon* that can be applied if there, and we all hope there is not, if there is another oil spill disaster like that.

But, again, I would like to follow up with you on some of those technologies.

Next, Arctic strategy. We sent a letter last month to the Commandant and the CNO [Chief of Naval Operations] regarding a joint Arctic strategy. I think a number of us are very concerned, and I think I can speak for everyone up on this panel. All of us are very concerned about the apparent separate or siloed Arctic strategy approaches by the Navy and the Coast Guard.

Obviously, both of you are critical in that region. We have seen the advances of Russia, China, and other countries. We have discussed it ad nauseum in this committee about the fact that the United States is far behind other Arctic nations in terms of capabilities, icebreaking and others.

Could you talk a little bit about the importance of a joint strategy, what you all are doing to have a joint strategy with the Navy?

Admiral HAYCOCK. You have indicated, and I think we would recognize, that working together with the Navy is an important part of the Arctic strategy, and I think we would welcome that and we would go after that.

I don't have the details because that is more of an operational concern. I would really need to get back to you on that one, sir. I wish I could answer that.

Mr. GRAVES OF LOUISIANA. Admiral, again, I think it is very important that we have a joint strategy. You all worked seamlessly with the Navy in other parts of the world. You do a great job. You have a common mission. Your platforms are compatible. I think that all of us feel very strongly that having a similar relationship with the Navy in the Arctic is important.

The last question: Could you talk a little bit about, and I think this is in your wheelhouse, the role of dynamic positioning autonomous vehicles and others in the Arctic and how perhaps advances in regard to Arctic platforms, how those two issues come into play there?

Admiral HAYCOCK. Autonomous systems are a very important part of the future in the Arctic. We need to make sure that vessels navigating in the Arctic regions and those that are taking station up there for resources, oil exploration, that sort of thing are safe and can operate up there, basically responding to all of the risks and such.

So we welcome the opportunity to work with industry to further explore those things.

You talked a little bit about the *Deepwater Horizon* and some of the folks down in your area that have developed some interesting lessons learned and some technologies. We welcome the oppor-

tunity to work with those folks to take advantage of those technologies.

Really what it comes down to, sir, is if we are aware of something that goes on, we are interested in trying to take advantage of it and leverage it for the purposes of maritime safety.

Mr. GRAVES OF LOUISIANA. I just want to clarify that I am talking about for purposes of the Coast Guard's assets, the role that dynamic positioning and autonomous in Coast Guard assets, but I know I am over time. Let me yield back.

Mr. HUNTER. I thank the gentleman.

Ms. Plaskett, you are recognized.

Ms. PLASKETT. Thank you very much.

Thank you so much for being here and providing this testimony in what I think is really important technology that you are working on.

I wanted to ask you questions that were more related not so much to the research, but the application of the technology in different areas, and the first one is with regard to some of your duties and your mandate in the Caribbean related to illegal drug trafficking.

There is a tremendous flow of drugs and weapons between the U.S. Virgin Islands, the British Virgin Islands, the area of Puerto Rico. On all sides, all of these islands are completely surrounded by water, and you all stand in many instances as the first line of defense for us in the flow of those drugs and weapons from the Virgin Islands into the mainland.

And what I was wondering is some of the technology that you have spoken about today and is in your written testimony. What is the application of those technologies in that area, and how might it be used to further stem the flow of those illegal drugs and weapons?

Admiral HAYCOCK. So some of the technologies that can be used up there include biometrics and improving our intelligence, surveillance, and reconnaissance capabilities through the use of UAS. In particular, the biometrics, we have employed that starting with our 110-foot patrol boats a number of years back, and we have actually taken that program and expanded it to other assets, such as the Fast Response Cutters.

Really our key is to identify those threats before they make landfall, push our borders out, and so our use of things like the UAS and having that ability to identify those threats far out is probably the first key.

Ms. PLASKETT. And how does the technology do that?

How do you improve the maritime domain awareness to be able to do that since there is no way you could have sufficient number of actual vessels in the waters to be able to protect the islands?

Admiral HAYCOCK. Thank you.

We work with other agencies in terms of law enforcement. So we work with DoD employing some of their ISR capabilities. We work with the FBI [Federal Bureau of Investigation] and other organizations, and we share information.

So the information that we get, that we get from our assets, we feed that common operational picture for the other agencies, and we extract information from that as well so we can do a better job

at being at the right place at the right time to engage with the trafficking.

Ms. PLASKETT. OK. I guess I was just trying to drill down into was there any specific technologies that would be more helpful or that you have been testing to be able to utilize in this area, but I understand your joint work with HIDTA [High Intensity Drug Trafficking Areas], in particular, and DEA [Drug Enforcement Administration] and others is really a first line of defense is what you are saying, correct?

Admiral HAYCOCK. That is correct.

Ms. PLASKETT. OK. One of the other things that is a concern to me, particularly the announcement. For many years we had an oil refinery in the Virgin Islands, and it is my understanding that our Governor is closing the deal on that reopening.

Because the natural resources of the island are so particularly important to us, I am very concerned, and there are discussions of an underwater pipeline to be able to keep the vessels further offshore and pipe them into for refining.

Can you tell me? I always have a concern about maritime accidents, as oil spills or grounding pose detrimental impact.

Is the Coast Guard pursuing any new technologies to respond to oil spills or other maritime disasters which occur not just in the Caribbean, but on the gulf, in California, and other areas as well?

Admiral HAYCOCK. The R&D Center has a lot of different projects that we work on, and we get $500,000 a year coming out of the Oil Spill Liability Trust Fund. We put that money to good use trying to find ways to mitigate accidents that have already occurred and to prevent accidents from occurring as well.

Our prevention folks, the community of the Coast Guard that tries to prevent these sorts of things, works hard to train their people to make sure they know how to go about identifying problems before they occur, and then we try to share information we get, and we hold people accountable when they don't do what they are supposed to do to keep things safe.

Ms. PLASKETT. Is this the use of crowd sourcing that you were talking about?

In other areas that you have utilized, is this also utilized in oil spills or other natural disasters?

Admiral HAYCOCK. Yes, ma'am.

Ms. PLASKETT. OK. And from that crowd sourcing, are there partnerships that you have with private sector technology companies that might be utilized for more rapid response and mitigation of the damages from some of these?

Admiral HAYCOCK. Yes, there are lots of opportunities there. The cooperative research and development agreements are one method we use to get with industry, to form partnerships.

We provide an opportunity for them to get on the Coast Guard assets and test things, and then we have the opportunity to learn more about it and figure out how to adapt that for use in the Coast Guard.

Ms. PLASKETT. Do you find that is really helpful having those partnerships with those technology companies or others? Is that working well, not just in terms of the technology and its applica-

tion, but as Ranking Member Garamendi said, then being able to adapt to the culture of the Coast Guard, as well?

Admiral HAYCOCK. Yes. These CRADAs have been very, very beneficial to us. It is a great relationship we have with our partners, and we are looking for ways to create more.

Ms. PLASKETT. OK. Thank you.

No further questions at this time. I yield back.

Mr. HUNTER. I thank the gentlelady.

I think to Mr. Graves' questions, too, really quickly, you are the Chief Acquisition Officer of the Coast Guard. So when he talks about the operation, I understand you are not the operational guy for the Coast Guard, but you are going to be the one answering and hearing all the operational needs when they ask you to then acquire a piece of gear to meet those needs.

So you know. You have the answer to his question, whether you know it or not, because you are hearing what they want to acquire, and you will hear because that is what your job is.

So, Mr. Graves, to your point, the Admiral is the Chief Acquisition Officer for the Coast Guard. So he is not the operational requirements guy for the polar icebreaker, but he is going to be getting all of the requests for all the gear that will fulfill the operational requirement needs.

So you are the right guy to talk to, and I think you will have those answers going forward on what the Joint Program Office is looking for to be able to fulfill all needs, and I just hope that we make that bigger.

I think you got my point earlier. There is no difference launching a UAS from a Coast Guard vessel and a Navy vessel. There is no difference.

There is no difference shooting off of a Coast Guard vessel and shooting off of a Naval vessel. There is no difference launching a helicopter off a Coast Guard vessel and a Naval vessel as long as they are the same sized vessels. There is no difference, in the ocean, on a ship, and it is the same thing.

So why did it take 5 years to get a loudspeaker on Coast Guard ships? It is a mounting issue. I know you cannot mount it where the guns are and stuff. I get it, but it took 5 years to get a speaker, which is one of the Coast Guard's core competencies, is to keep people out of certain areas where you yell at people.

It is not a Navy core competency, but it took 5 years. I was so surprised that the Coast Guard did not have these LRADs on the ship. It blew my mind, and that the Navy did. It should have been vice versa.

But I just hope that you look at not necessarily Joint Program Offices, but look at what the Navy is doing and not recreating the wheel, not doing RDT&E because you don't need to. They have already done it.

And if we can change the rules or change the law so that you can piggyback on the Navy more so that you don't have to go through steps A through D and you can just jump to E, that would be great, and I think that is what we are kind of pushing for here.

So, Admiral, thank you very much. Thanks for being here, and thank you for your testimony and service.

Admiral HAYCOCK. It is an honor to be here.

Mr. HUNTER. And we are going to move to the second panel. While everybody is moving around, I will introduce. Actually we can wait. Take your time.

All right. Lady and gentlemen, welcome. We will now move to the second panel.

We will hear from Dr. Eric Terrill, director of the Coastal Observing Research and Development Center at the Scripps Institution of Oceanography. That is a great place. I go there all the time, to surf, back in the old days.

Mr. Michael Jones, president of The Maritime Alliance.

Mr. Chris Coyle, member of the International Ocean Science and Technology Industry Association.

Mr. Thomas Chance, chief executive officer of ASV Global.

Dr. Tuba Ozkan-Haller, professor and associate dean at the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University.

And Rear Admiral Jonathan White, president and chief executive officer of the Consortium for Ocean Leadership.

Dr. Terrill, we realize, too, that you have to leave at 11:45. So just feel free to hop up and roll when you have got to go. We now recognize you to give your statement.

TESTIMONY OF ERIC J. TERRILL, PH.D., DIRECTOR, COASTAL OBSERVING RESEARCH AND DEVELOPMENT CENTER, SCRIPPS INSTITUTION OF OCEANOGRAPHY; MICHAEL B. JONES, PRESIDENT, THE MARITIME ALLIANCE; THOMAS S. CHANCE, CHIEF EXECUTIVE OFFICER, ASV GLOBAL, LLC; CHRISTOPHER J. COYLE, MEMBER, INTERNATIONAL OCEAN SCIENCE AND TECHNOLOGY INDUSTRY ASSOCIATION; H. TUBA OZKAN-HALLER, PH.D., PROFESSOR AND ASSOCIATE DEAN, COLLEGE OF EARTH, OCEAN, AND ATMOSPHERIC SCIENCES, OREGON STATE UNIVERSITY; AND REAR ADMIRAL JONATHAN WHITE, U.S. NAVY (RET.), PRESIDENT AND CHIEF EXECUTIVE OFFICER, CONSORTIUM FOR OCEAN LEADERSHIP

Dr. TERRILL. Chairman Hunter, Ranking Member Garamendi, and members of the subcommittee, thank you for the opportunity to be here today and discuss new maritime technologies.

As I was introduced, my name is Eric Terrill, and I am the director of the Coastal Observing R&D Center at Scripps in San Diego and have 25 years' experience as an oceanographer, leading basic and applied research programs around the globe.

In the interest of brevity, I shall forgo Scripps' very long history of supporting national defense objectives, but that legacy is captured in my written testimony.

So my testimony, I will address three points: the merits of the Coast Guard developing partnerships with organizations and agencies that specialize in conducting maritime RDT&E; using existing maritime technologies tailored to the Coast Guard mission; and exploitation of data and products from existing networks to enhance Coast Guard mission readiness.

In 2002, at Joint Harbor Operations Center, the one that was referred to in your introductory remarks, Chairman, was developed after the events of 9/11, and in the center, dispatchers worked side

by side across a whole range of agencies, including National Guard, Customs and Border Protection, ICE [U.S. Immigration and Customs Enforcement], and various other personnel.

And the JHOC is an analog for the type of interagency partnering that will be required if there is an expectation to efficiently field modern blue technologies with the Coast Guard.

In the history of Scripps, my organization has maintained a strong emphasis on the development, testing and evaluation of maritime platforms and sensors for the purposes of persistent ocean sampling, and in many cases, these capabilities are directly relevant to the men and women who provide maritime security to our Nation.

UUVs, or unmanned underwater vehicles, continue to develop as a frontier technology for subsurface exploration and sensing advances. These vehicles, with appropriate sensors, payloads can assist the Coast Guard in detecting and tracking oil spills of unknown origin; finding sunken wrecks and assessing their potential to leak bunker oil; mapping bathymetry hazards in marine habitats; and detecting IUU, or illegal fishing activities.

Unmanned surface vessels are maturing, as well, as another maritime platform for consideration to serve the maritime security mission, and contrary to underwater vehicles, their ever-present surface expression provides and always-on communication, ISR, and navigation capabilities with GPS.

In my experience with unmanned surface craft, you referred to your trip up to Silicon Valley to see debris 6 years ago. That debris has now matured to a commercially available platform through a company called Liquid Robotics. We have had a wide range of successes in a range of operating environments with that platform.

And applicability to the Coast Guard includes ship traffic monitoring, fisheries protection, ocean sea state characterization, and monitoring of currents in support of oil spill trajectory analysis; communication gateways between surface craft and ship routing.

Unmanned aerial systems are another tool that could be transitioned. A lot of discussion earlier this morning on that. An emergent technology of interest in that regime is the hybrid UAS that allows for vertical and takeoff from a fixed location, but transit with a fixed wing similar to an Osprey. So now you have not the load-out that you might have with a catapult type system or the ScanEagle.

These capabilities are only now in development for use from ships operating on the high seas.

Scripps recommends partnering within the Department of Defense. They are already making investments in developing maritime surveillance tech systems. Office of Naval Research is an example of an Echelon 1 command which invests in RDT&E to routinely conduct small scale demonstrations for developing and testing new concepts of operations and technologies and leverages the expertise and testing of their program managers in operating efficient RDT&E programs.

Science and technology in a spiral development with an emphasis on at-sea testing allows the capability to incrementally evolve and improve at lower risk. Successful demonstrations can be transitioned to support operations, while unsuccessful demonstra-

tions provide valuable lessons learned before you field it to a whole fleet.

Along the U.S. coast, there is a wide network of 168 high-frequency radars sponsored by NOAA [National Oceanic and Atmospheric Administration]. Through MOUs [memorandums of understanding] they provide this information to the Coast Guard for missions, such as oil spill and response and search and rescue and operations.

This is an operational network. However, the opportunity remains elusive to continue to exploit that system because it is only funded at the 50-percent level at which it was originally earmarked or identified in a national plan to get that radar network in operation.

So in closing, I would like to thank the committee for the opportunity to testify on the role of marine technologies and provide suggestions for U.S. to leverage ongoing investments and use new maritime technologies to improve maritime mission performance and efficiencies.

Thank you.

Mr. HUNTER. Thank you, Mr. Terrill.

Mr. Jones, great to see you out here. You are recognized.

Mr. JONES. Chairman Hunter, Ranking Member Garamendi, members of the subcommittee, thank you for the opportunity.

I am president of The Maritime Alliance. We are a nonprofit industry association founded in 2007 and based in San Diego. We are a leading voice for blue tech nationally and internationally.

We are a multiyear strategic partner with the U.S. Department of Commerce and received a grant to organize the first ever U.S. Maritime Technology Export Initiative.

In 2017, we helped form the BlueTech Cluster Alliance, the first international coalition of blue tech clusters.

The Blue economy is enormous and growing. It is blue tech that allows us to understand ocean problems, and blue tech is critical to develop solutions to these problems. And blue tech companies are providing the innovative tools and services that permit emerging ocean industries to develop.

The Maritime Alliance has over 90 members from across the U.S. and internationally. In conjunction with our international cluster partners, we have access to thousands of companies.

The following are some maritime issues that The Maritime Alliance blue tech member companies are addressing that may be of interest to the Coast Guard.

First, on autonomy software and autonomous vessels. Multiple TMA [The Maritime Alliance] member companies are involved in autonomy in the air, on, and under the water. As examples, Boston-based Sea Machines Robotics recently announced a contract with Maersk, the world's largest shipping company, to try out the world's first artificial intelligence powered situational awareness system aboard a containership.

And San Diego-based Planck Aerosystems' drone intelligence improves real-time situational awareness via autonomous takeoff and landing from moving vessels at sea.

Second, under big data, enormous amounts of ocean data are being collected. Redlands, California-based Esri, the world's leading

GIS software mapping company, is helping unlock the potential of data to improve operational and business results.

And San Diego-based XST provides big data consulting services, including high-definition, hyper-local weather prediction.

Third, in cybersecurity, we know good cyber hygiene, training, and innovative technologies and services are needed to protect the logistics chain. Philadelphia-based Gnostech helped mitigate cybersecurity risk from sea to shore.

Fourth, in ocean observation, the Integrated Ocean Observing System, IOOS, is the national-regional partnership focused on ocean observation and enjoys wide industry support.

TMA was coauthor of "The Ocean Enterprise," the first ever national scale assessment of the value of ocean observation published in February 2016 that identified over 400 U.S. companies in 36 States, representing over $7 billion in revenue.

Fifth, in pollution mitigation, San Diego-based Earthwise Sorbents is pioneering high-performance algae-based, not petroleum but algae-based sorbents to clean up oil and chemical spills on land and in water.

Seattle-based Marine Construction Technologies has patented an innovative pile design that reduces noise pollution from impact pile driving by 80 to 90 percent.

Sixth, port and maritime efficiency and security. Durham, North Carolina-based PortCall and San Ramon, California-based OceanManager have developed maritime software to help port and shipowners to be more efficient.

Richmond, California-based WAM–V produces a watercraft using patented suspension technology to radically improve seagoing capabilities.

And seventh, in predictive analytics, Seattle-based ioCurrents gathers real-time data on important assets on commercial vessels into a central database onboard to permit automated analysis within the cloud's availability and backup. This allows operators to predict and preemptively resolve likely equipment failures.

So following are some ideas for the subcommittee to consider to enhance the Coast Guard's ability to identify, test, and incorporate blue tech:

Increase travel funding to attend blue tech oriented events;

Increase funding to evaluate blue tech products and services;

Enhance the on-ramp to make it easier to identify innovative technology and services;

Enhance the Innovation Council with regional meetings alongside blue tech events;

Make regional tech scouting part of someone's role;

Establish a secondary innovation center on the U.S. west coast;

Promote blue tech collaboration with other U.S. Government agencies in the marine domain;

Promote blue tech collaboration and transfer to and from other countries' forces.

Thanks for the opportunity to testify today. We are grateful to the members of the subcommittee for focusing on blue tech. The Maritime Alliance stands ready to be a resource to this committee.

I request that the entirety of my written testimony be entered into the record of this hearing.

Thank you.

Mr. HUNTER. Thank you very much.

I just want to sing Michael's praises. No one has done what he has done yet, creating a blue tech consortium that someone can go to as a single point. They have this for everybody else, but no one thought to do it on the water, and it is pretty amazing, a lot of money, and it gives the Coast Guard and the Navy and other organizations a single point to go to say, "Hey, what is out there?"

But thank you for all that you are doing.

Mr. Chance, you are recognized for your statement.

Mr. CHANCE. Thank you very much.

To help us stay on schedule, I will summarize my written testimony.

Chairman Hunter, Ranking Member Garamendi, and distinguished members of the committee, I am honored to testify today regarding the use of new maritime technologies to improve the efficiency and mission performance of the U.S. Coast Guard.

As CEO of ASV Global, the world's largest and most experienced unmanned surface vehicle company, I can speak as to where unmanned vessel technology is today and where it is going.

However, before I do so, let me commend the work of the U.S. Coast Guard and this subcommittee for its long history of outstanding service. The Coast Guard is saving lives, fighting crime, and defending our country on a daily basis, and the citizens of this country should never take that for granted.

Unmanned surface vehicles, or USVs, are simply unmanned boats. Our company alone has delivered more than 100 USVs to military and commercial users across the globe. These USVs have ranged up to 40 feet in length, up to 1,000 horsepower, and endurance in excess of 30 days. However, we currently have several inquiries, both commercial and military, for unmanned vessels in the 80-foot to 200-foot range with endurance up to 3 months.

Leidos Corporation recently built a 132-foot USV, while the Norwegians and the Chinese are starting to build USVs up to 260 feet in length.

In addition to USVs that cannot accommodate personnel, industry has built dozens of optionally unmanned vessels. Optionally unmanned allows the asset to be deployed with a full crew onboard, a reduced crew, or no crew at all.

Finally, ASV Global has upgraded several existing vessels to optionally unmanned. By upgrading to optionally unmanned, existing assets can experience the progression to unmanned without losing existing capabilities.

Just as driverless cars have a steering wheel and a driver's seat, the current pragmatic approach to driverless vessels is to allow them to drive autonomously while remotely supervising their operation over a radio or satellite telemetry link.

At the same time, COLREG [International Regulations for Preventing Collisions at Sea] compliant collision avoidance software continues to mature so that remote supervision can eventually be phased out.

Economics is the driving force towards the use of unmanned vessels. When you go from manned to unmanned ships, you don't need a galley and a mess. You don't need bunk rooms, hallways, heads,

washing machines, dishwashers, freezer, stairways, workshops, a meeting room, or a large bridge. In a sense, an unmanned vessel is a hull with diesel tanks, engines, and a rack of computers and sensors.

While I don't want to trivialize what is necessary for unmanned vessel operations, the capital cost of an unmanned vessel can be far less than that of its manned equivalent.

In addition to reduced capital costs, unmanned vessels can offer reduced daily operating costs as vessel personnel are condensed to those remotely supervising operations and those maintaining unmanned vessels while at port.

Finally, CONOPS, such as offshore stationing, can substantially reduce operating costs.

USVs can offer persistent maritime domain awareness, where unmanned or optionally unmanned vessels, large or small, can remain on station for weeks at a time, while providing intelligence, surveillance, and reconnaissance, as well as interception and to a degree, interdiction.

Coast Guard personnel at land-based command centers can dispatch predeployed unmanned vessels to intercept and assess. Nonlethal weapons, such as prop-net entanglement systems, can be used by USVs to stop suspect vessels until manned Coast Guard vessels can arrive and apprehend.

Offshore stationed USVs can be used for drug interdiction, illegal fishing interdiction, border protection, collision investigations, search and rescue, pollution incident investigations, and investigation of the numerous reported suspect vessels in distress.

Coast Guard vessels of all sizes are candidates for upgrades with collision avoidance bridge aids to mitigate maritime collisions. Future ship build programs should certainly consider fully unmanned, partially unmanned, and optionally unmanned ships.

These are just a few of the many applications of unmanned surface vessel technology that can be considered by the U.S. Coast Guard. While additional appropriations are necessary for the Coast Guard to capitalize on unmanned technology, the economic and strategic advantages are likely to be overwhelmingly positive as they are with other unmanned technologies in the military and commercial sectors.

I would be happy to answer any questions that you may have.

Mr. HUNTER. Thank you, Mr. Chance.

Mr. Coyle, you are recognized for your statement.

Mr. COYLE. Good morning. My name is Christopher Coyle. I want to thank the chairman, ranking member, and distinguished committee for giving me the opportunity to speak to you today about blue technologies, an exciting field.

Today I am representing IOSTIA, the International Ocean Science and Technology Industry Association, which represents businesses and organizations that provide technology and services for sectors that sustainably and commercially utilize the oceans.

As an example of this hearing, IOSTIA provides a unified public policy voice for those in the industry space.

During the day I work for Exocetus Autonomous Systems, a company that designs, manufactures, and services deep-sea robots, au-

tonomous underwater vehicles, or AUVs, in business development and strategic partnerships.

I also lead the company's data and analytic initiative for the company's XPRIZE entry. In fact, Exocetus was named a semifinalist in the Shell Ocean Discovery XPRIZE for mapping the ocean floor. We were only one of 19 teams selected from around the world out of 1,400 entrants. So we are extremely proud of this moon-shot award.

In addition, Exocetus is a semifinalist in NOAA's prize for detecting chemical and biological signals underwater.

Our oceans cover 70 percent of the planet. Yet only 10 percent of the ocean floor has been mapped. We know more about the surface of the moon than we know about what lies below the surface of our waters.

How is that possible?

Elon Musk, Jeff Bezos and Richard Branson have spent billions of dollars of their own wealth and raised billions more from Silicon Valley investors. It is sexy and exciting. Yet, they have reenergized the planet's interest in outer space, intergalactic travel, and potential colonization of other planets.

But it is entirely misguided. The final frontier to be discovered is our oceans. The next space race is our oceans. Our planet depends on the access to healthy and plentiful oceans. Blue tech should be the focus, not space.

As population growth climbs, as migration to concentrated coastal areas continues, as farmlands around the world shrink, as more and more people become dependent on fish protein, as seas play a more herculean role in carbon capture, oceans need to be today's focus for emerging technology, investments, and U.S. Government attention.

And so blue technology is the critical technology to encourage as our children grow into adults and take on leadership roles.

This past week, I came across an article entitled "Can the U.S. Navy Brave the Waves of Autonomous Warfare?" I will hand the article to your staff in case you would like to include it in the record today.

The article's thesis is that AUVs offer greater efficiency, mission range, and lower cost of capital than other more traditional naval means. AUVs will prove to be cheaper to operate, put fewer seamen in harm's way, and therefore, assume greater levels of risk.

AUVs are more expendable and can augment a fleet to do search and reconnaissance. Last July, DARPA contracted BAE Systems to build small AUVs to detect enemy subs. Today, AUVs are working on sea sensing and mine countermeasure tasks.

By 2025, the Navy's AUVs will support undersea warfare by going into denied waters that are either too deep or too shallow for manned platforms.

AUVs will continue to provide greater benefit to the U.S. Coast Guard for port and waterway security, maintaining aids to navigation, marine environmental protection, oil spill protection and response, marine pollution laws, fisheries, ocean shipping lanes, and in support of the Coast Guard Authorization Act of 2017.

My company, Exocetus, is a quintessential example of a sound U.S. Government collaboration. Exocetus was started with a $15

million Federal grant to develop its buoyance engine resulting in three patents on the engine design and one on the retrieval system. Today, we are proud to say the Navy presently is using our AUVs.

To me, the most exciting thing about AUVs are the sensors and the integration of all the emerging technologies, such as cloud computing, artificial intelligence, machine learning, and blockchain to process the big data and analytics that will provide essential information and intelligence for our national security, coastal erosion, port security, shipping lanes, laying fiber optic cables for communication, internet and media companies, and meteorological disturbances, to name just a few.

The future for blue technology is bright. The million-dollar question is: Are we going to seize this amazing opportunity and support and invest in brandnew industries that will create high-paying jobs of the future, or are we going to continue to kick the can down the street? If we don't, the Chinese and the Russians will.

I am convinced that the potential for the blue economy and blue tech will be the next biggest revolution that we have seen in decades. The best way to predict the future is to create it.

Thank you and I look forward to answering any of your questions.

Mr. HUNTER. Thank you, Mr. Coyle.

Dr. Ozkan-Haller, you are recognized for your statement.

Dr. OZKAN-HALLER. Thank you, Chairman Hunter, Ranking Member Garamendi, and members of the subcommittee, for the opportunity to testify today on blue technologies developed within academic settings and how they can support the Coast Guard's mission.

I am a professor at Oregon State University, and I conduct research on the prediction and forecasting of ocean conditions. My work also explores ways to present forecast results to make them most usable for various stakeholders, including bar pilots, the fishing community, the National Weather Service, and the Coast Guard.

My testimony today will focus on the potential for wave forecasting systems and other forecasting innovations to help advance operational capabilities of the Coast Guard, including safe navigation and identification of illegal activities at sea.

The development and refinement of these forecasting tools heavily relies on observations of the ocean both from long-term observing platforms, as well as from innovative autonomous platforms that you have already heard about this morning.

Today I will stress that strategic investments are required in technology development and in continuing education activities to ensure the effective utilization of these technologies to meet the mission objectives of the Coast Guard.

First, ocean wave and current forecasts are analytical tools that can help stakeholders understand and predict ocean conditions. Recent advances in predictive models allow for detailed and high-resolution forecasts of ocean conditions.

Forecasts in the open ocean can be used during search and rescue operations to narrow down the geographical area of interest. Forecasts near navigational inlets are a critical capability at many

challenging inlets where transit through the river mouth and over the river bar can be treacherous.

The mouth of the Columbia River, often colloquially referred to as "the graveyard of the Pacific," is one such example. Twenty-four billion dollars of cargo moves through the Columbia River system annually. The Coast Guard makes decisions about bar closures that halt vessel traffic, and the cost of a bar closure to the local economy is significant.

One of the groups that plays a role in bar closure decisions is the Columbia River Bar Pilots. They require accurate forecasts 10 hours in advance because of the time required by a tanker released from the upriver port to reach the river mouth.

Once there, most of these tankers are too big to turn around, so the hazard of making a wrong decision can mean a disaster on the bar.

For the last 5 years, the Columbia River Bar Pilots have been utilizing our wave forecasts to inform their decisionmaking on navigational planning. We have worked extensively and iteratively with the bar pilots to create an interface that meets their needs and maximizes their ability to use the results.

They now use forecasts for the computation of under-keel clearance values, as well as for recommendations regarding the closure of the bar, along with, perhaps more critically, the timing of the reopening of the bar.

Additionally, predictive forecasting capabilities also now show promise for identifying illegal activities at sea. Illegal, unreported, and unregulated activities at sea can be challenging to assess and predict. The key challenge is that vessels committing IUU activities turn off their GPS transponders and, therefore, go dark.

New solutions for predicting IUU activity using mathematical models based on conflict systems theories are currently emerging, and these methods exploit the fact that vessel traffic responds to the presence and absence of other vessels in the area whether they are visible to us or dark. So observing the behavior of the visible fleet carries clues about the movement of the dark fleet.

While this research is still in very early stages, further development of these methods could aid in more efficient and effective patrol strategies.

Finally, there is rapid advancement in research and technology innovation, but strategic investment in technology development by the user, in this case the Coast Guard, is critical to assure that any technology of interest is designed to meet their specific capability objectives.

Our experience with wave forecasting products suggests that the needs of the bar pilots are quite different from the needs of the tuna fishing industry, for instance. Hence, close engagement is needed during the development phase of the products, and coordinated education is essential to assure the effective utilization of blue technologies by Coast Guard personnel.

In closing, research and innovation in the field of ocean wave and current forecasting is proving to be increasingly significant in its potential to be translated into technology and information systems for the Coast Guard.

I thank the subcommittee for your efforts to consider the role of technology innovation and applications for efficiently and effectively advancing critical Coast Guard capabilities, and I would be pleased to answer any questions.

Mr. HUNTER. Thank you, Doctor, for your testimony.

Admiral White, you are recognized for your statement.

Admiral WHITE. Thank you, Chairman Hunter and Ranking Member Garamendi and honored members of the subcommittee.

During my 32-year career in the Navy, culminating in my assignment as oceanographer and navigator in the Navy, I worked with the Coast Guard at sea and ashore. Thus, it is with great respect and appreciation for their service that I am before you today to discuss blue tech on behalf of the Consortium for Ocean Leadership, which represents the Nation's leading ocean science, education, and technology institutions, industries, and others with the mission to shape the future of ocean science, and many of those institutions are represented on this panel today.

There are three important ideas to take away from my testimony.

One is that ocean knowledge enables the U.S. Coast Guard to achieve its missions through enhanced maritime domain awareness.

Two, that blue tech is vital to understanding the ocean.

Three is that blue tech innovation relies on ocean science, technology, engineering, and math education or "ocean STEM," as I call it.

This flow from mission success, from ocean knowledge, from blue tech, from ocean STEM education is the best way to understand how marine technologies not only improve efficiencies and performance, but are the very foundation that the Coast Guard relies on to meet its mandated missions now and in the future.

Now I am going to dive into my first two themes on ocean knowledge and blue tech as they enhance maritime domain awareness.

The late Admiral James D. Watkins, former Chief, Naval Operations, used to declare that oceanography won the Cold War, meaning that our superior ocean knowledge provided us with operational and strategic advantage over the Soviet Union.

It is paramount that the Coast Guard maintains its strategic advantage in the maritime domain against today's threats to our security and safety. Ocean research and blue tech provide the critical base to ensure this strategic advantage continues.

We must be able to exploit our superior knowledge of the ocean environment to ensure home field advantage at both the home and away games. We can only do that if we have unsurpassed ocean knowledge, which brings me to the importance of blue tech.

So how do we monitor, explore, map, and better understand the ocean environment that makes up 71 percent of our planet and surrounds our maritime Nation? It is ocean science and technology, and blue tech has provided our Nation with the knowledge advantage against myriad marine threats.

The Coast Guard, like all of our maritime forces, must optimize technological development to best understand the environment to meet its mission objectives while minimizing risk to personnel.

For example, the autonomous ocean vehicles and sensors that we have talked about already today with ever-increasing endurance and proliferation enhance our ocean knowledge and understanding, but can also serve a dual use of surveillance and monitoring and of the activity on, under, and above the ocean surface.

With collaborative partnerships among Federal agencies, ocean science and technology institutions and industry, these are essential to actualizing the potential of blue tech like this to fulfill the Coast Guard's missions.

In my written testimony, I go into more detail on what it looks like in the real world with examples of how understanding the ocean and using blue tech will advance our Nation, whether it is helping the Coast Guard to catch the vessels fishing around the world illegally in our own waters, or allowing us to safely and sustainably maximize new economic opportunities in the changing Arctic, or continuing to improve our preparations in responses to hurricanes and storms that threatened our safety and security.

I would be happy to expand more on those examples during questions.

So it is clear to me without continuing to grow our ocean STEM education base, the Coast Guard will be unable to maximize technology developments and meet their missions. Other nations are advancing rapidly with the hope of overtaking the U.S. in the global scientific and technical fields as a super power. Increasing our ocean STEM education and training will ensure our sailors and civilians have the requisite skills to embrace new and emerging blue tech ahead of competing entities and threats.

I encourage this committee to join others in supporting Federal investments in the prioritization of STEM education to enable programs like those at the Coast Guard Academy and develop the next generation of maritime innovators and servicemembers.

It is really rather simple. Greater technology requires greater technicians, and that requires enhanced ocean STEM education.

To respond to our ocean's physical, chemical, and biological changes while maintaining security around our geopolitical maritime boundaries and ensuring the safety and prosperity of those within them, the Coast Guard must know the ocean.

Chairman Hunter, Ranking Member Garamendi, and Members, the ocean science and technology community appreciates the interest that this subcommittee has in blue tech, and I want to reiterate those three points:

Ocean knowledge enables the Coast Guard to achieve its missions through enhanced maritime domain awareness;

Blue tech is vital to understanding the ocean;

And blue tech innovation relies on ocean STEM education.

I thank you for the time and the opportunity to be before you, and I am ready to answer questions.

Mr. HUNTER. Admiral, thank you.

I am going to take us back to the late 1990s when the Air Force was looking at these unmanned aerial vehicles. At that time it was Predators. So picture a bunch of Air Force officers, mostly generals and colonels, all pilots, the head of the Air Force, and we come up and we say, "Hey, we would like you guys to look at unmanned aerial vehicles."

And they are like, "What do you mean? Ones that we are not in flying?"

We say, "Yeah, ones that you can fly from the ground that a 19-year-old can fly with an Xbox controller. How about those?"

And the Air Force said, "Go pound sand," or, "go pound clouds." I don't know what the Air Force says, but the Air Force said no because a bunch of pilots in the Air Force did not want an unmanned aerial vehicle. It was a culture shift for them.

This Congress, and it was back in the day, the late 1990s, the appropriators in the Armed Services Committee said, "Air Force, you will have Predators. Here you go. Here are some Predators. Learn how to do it."

The Air Force had to accept that, and it was a massive culture change for them because they had a lot of excuses, airplanes hitting each other; not a real pilot flying them; a lot of different things.

We now see in warfare what a Predator does or a ScanEagle or a Pioneer or any of these different things that we use to support our men and women around the world very inexpensively and effectively.

It seems like that is where the Coast Guard is at now, except the analogy would be different. It would be if the commercial world had been using Predators for 5 years and the Air Force finally jumped onboard. That is where the Coast Guard is now.

So they are behind the commercial world. They are behind the Navy. They basically don't exist in this world at all, except for looking at different programs and testing and evaluating them. They are not playing yet, while this stuff is being used commercially.

So it has gone backwards, and I guess our job in the committee and your job letting us know what is available is to make them adapt and change so that they can be more effective.

So, Admiral, I guess my first question to you is you have things. You have RPVs, remotely piloted vehicles, unmanned underwater vehicles, autonomous vehicles. You have the liquid robotic surfboard which can be maneuvered and is autonomous, too. It can be programmed. You have an unmanned surface vehicle right now in San Diego in Point Loma that the Navy is using. It was going to be in the big RIMPAC [Rim of the Pacific Exercise] coming up. They are going to actually use it, one of the first autonomous vehicles there.

I guess I am throwing this all at you, Admiral, to start off with because you were in the Navy while they have gone through these kinds of changes in culture of looking at these things as well. They are much more embracing of this, it seems, than the Coast Guard is, and I guess the question is: why is that?

And what can we do in this committee to make the Coast Guard embrace what the Navy has and kind of get out of the culture of "wow, if we cannot drive the boat, we don't want anybody to drive the boat"?

And I would end with this. At least for cuing, meaning foreseeing the bad guys driving, the Coast Guard could spend $20 million tomorrow and have a 50-mile line coming out from San Diego with surfboards that could recognize any ship going over 40 miles an

hour. That exists very easily right now that can tip and cue them then to go get it.

The Coast Guard's reason is we cannot catch these guys. We don't see half of them. When we see them, we can usually hit them. It is hard to see these panga boats coming up the coast of California.

You can create a tripwire really easily. It is not in their concept of operations. They talk about it, but the technology has existed now for years, and it is out there. They are not doing it.

So I guess the question to you is: Coming after 30 years in the Navy, being their oceanographer, being the guy watching the culture in the Navy, where is the Coast Guard in terms of culture, and is that what needs to be changed, looking at Mr. Garamendi's questions earlier in the last panel?

Is that what needs to be changed in the Coast Guard or is it really that they need to change laws and regulations to do these little things, or is it a personality issue?

Admiral WHITE. I certainly won't perceive to have the knowledge that our predecessor on the panel does of the Coast Guard's acquisition and research process, but I will tell you that the Navy's is the strongest pretty much in the world.

Over time we have showed the innovation, whether it is submarines, it is landing airplanes on aircraft carriers, and many things that you have talked about. That ocean research enterprise that the Navy has put forward has really adopted transformational changes which have impacted all of these services.

The Navy has always been committed to that. They spend a lot of money. They have a research, development and transition enterprise that, again, is like none other.

The Coast Guard and Navy work very closely, but in many ways, my own opinion is that the Coast Guard is always on the front lines. They are always right there. There are things going on on our coast, and they are stretched because of the operational type of responses and the operational readiness and preparedness, "semper paratus," that they always have to actually be there.

I believe there are opportunities, as I mentioned in my testimony, across agency working together in partnerships through things like the National Ocean Partnership Program Act, which was entered into operations in the 1997 National Defense Authorization Act.

Partnerships between the Department of Homeland Security, Transportation, DoD, NOAA, and others can advance the research and technology and transition if they are used appropriately, and I believe that is the type of avenue that you, sir, and your Members and partners in Congress can go forward and try to advance the research, development, and acquisition process of the Coast Guard.

Mr. HUNTER. What would you say was the biggest impediment for the Navy when it came to do an autonomous ship, for instance?

Because I have been in a room where you have a bunch of captains going, "We are not going to have a driverless ship. Every Navy ship will be captained." I mean, that was a culture issue.

Admiral WHITE. And when Secretary Mabus made the announcement 4 years ago at the Sea-Air-Space Exposition that the F–35

would be the last generation of manned fighter aircraft, naval aviators' jaws dropped on the table, as you can imagine.

So but what you have, I think, is a workforce based in STEM education over many decades who understands the importance of embracing new ideas and technology. I think that has been the U.S. Navy's strength. Especially now you see that more than ever.

So I think embracing that culture and blending that culture with industry and the academic institutions, which the Navy also does through its Office of Naval Research and the laboratories that were actually talked about, that is how the Navy has managed to do that.

But a lot of it is personality driven, and the U.S. Navy and the Coast Guard, I believe they have the right personality and the people in leadership to do that. It is just a matter of giving them the tools, the time, and the resources to do it right, sir.

Mr. HUNTER. So to extrapolate then on what you said, you are saying the Coast Guard is so operational all the time, it is your opinion that they don't necessarily have time to look into these things and operationalize them or it takes longer?

Admiral WHITE. Yes, sir. I believe they are stretched. I don't think they have time or the resources, and I don't think we in the Federal Government have the partnerships across the agencies to be able to accelerate transitions of the great work that the other members on this panel are doing in industry and academics.

Mr. HUNTER. But the catch-22 is that if the Coast Guard did some of these things, they would have more people to do other things and the ability to have some space there because of the leverage you get by employing autonomous anything in sensors.

Admiral WHITE. Yes, sir, but I always caution that we did learn a hard lesson in the Navy early on. Unmanned does not mean totally unmanned. It takes people to operate these systems, more and more technology, more and more knowledge, as I talked about it as well.

So I do caution you to not think too much that we are going to free up a lot of people because there is plenty of mission for the Coast Guard, the Navy, and all of our forces out there, sir.

Mr. HUNTER. Thank you, Admiral.

Mr. Garamendi, you are recognized.

Mr. GARAMENDI. First I want to thank the panel, an extraordinary panel, and a wide variety of information, from basic research to applied, and then the actual business of building the various systems. It is extraordinary.

And your testimony probably two or three flights across the country for the chairman and I to absorb all of the data that you have given me. So thank you so very much for that.

I have got about 20 different questions, and about 5 minutes in which to ask all of the questions. But really honing in on the culture of the Coast Guard here—but before I go to that, your testimony and, really, your work is based upon the application of science and research, much of which is funded through the various Federal organizations—National Science Foundation; for example, U.S. Navy, another example that was given here a moment ago. That is really beyond the scope of what we are talking about today.

But it is the application of that science, and the development of the various techniques and technologies that come from it that we are focused on. And most particularly on the culture of the Coast Guard.

I am sorry that the admiral left, but the reality is that there is within the Coast Guard two things operating, it seems to me. First the culture is not one of adapting quickly new techniques and technologies. And secondly, a lack of money to do so, if in fact that culture did exist.

So my—really, my questions go to—from your points of view and the work that you do, how can we encourage the Coast Guard to more quickly adopt the systems that you have developed, the research that you may have available, and just that area. So how can we motivate change or otherwise encourage the Coast Guard to be a first adopter of a technology?

Dr. Terrill, then right on down the line we can go at it.

Dr. TERRILL. Sure.

Mr. GARAMENDI. Money.

Dr. TERRILL. Well, I am not prepared to discuss procurement reform. But, as an observation, what I have seen in the Department of Defense, especially those parts of the Department of the Defense with seawater in their veins, is that the organized, vertically integrated programs that bring together the operational fleet all the way down to the R&D community, as part of these test beds or exercises that provide opportunities to demonstrate technologies to those in uniform, having them work together so that there is early adoption within those with uniforms so that they can be the apostles within their own organization to start—many times there is not an awareness of what the capabilities are. And having opportunities for the young lieutenants to actually be observant of the capabilities goes a long way, at least within the Navy.

Mr. GARAMENDI. Thank you.

Mr. Jones?

Mr. JONES. So we're not really the National Science Foundation level. We are talking about companies that are selling technologies. And my experience is the Coast Guard is extraordinarily operationally oriented. And so, to try and get the attention of people in various areas is very difficult. They want it to go through New London.

And I think one of the things that could be done—again, this is a cultural issue—is to encourage them to be looking for technologies, and to give them an opportunity to meet with industry.

I had a former Coast Guard officer say to me that some years ago he felt that it was much easier for him to work with and meet with technology companies, and that they no longer have their tech forum which they used to have 5 years ago, 6 years ago. They are no longer encouraged the same way—again, this is somebody telling me, so I am saying this thirdhand—that he felt like there wasn't the same exchange of information and opportunity between industry and Coast Guard. And again, that is a cultural issue.

So what I proposed was that each sector have people whose job it is—maybe it is 15 percent of the deputy commander's job—to go find technology, meet with industry, so they can funnel it up to

New London, rather than having it all centralized, and potentially putting something on the west coast.

So I think there are cultural things that—notwithstanding the fact it is extraordinary and operational every day, saving a life, you know, plus its military role—I think there are things that can and should be done.

Mr. GARAMENDI. Mr. Chance?

Mr. CHANCE. Sure, I would certainly second what you just said on the concept of having somebody concentrate on that, on meeting with industry and finding out what is available today.

I would also say that this hearing is already having its effect. You know, I am looking at it aggressively, which I probably didn't as much as I should have in the past, and now we are lining up meetings with the Coast Guard RDT&E. And seeing the funding that the Coast Guard has got more recently to be able to push in this direction is certainly going to help hugely.

Mr. GARAMENDI. Thank you.

Mr. COYLE. I can't speak necessarily to the culture of the Coast Guard, but I can say that some of the challenges that the Coast Guard probably faces in implementing some of this new technology, you see that same hesitancy within the tech community and the investment community, and the potential of the blue economy.

And so, trying to get IBMs and the Intels and the Oracles of the world to take those lessons learned in emerging technology and apply them to the ocean, the investment community, has been a herculean task. And I have only been doing this for a year. But that also allows for an enormous amount of opportunity to address those problems.

Mr. GARAMENDI. Thank you. Professor?

Dr. OZKAN-HALLER. Thank you for this question. I have spent the last 25 years of my career developing software tools that I thought could be useful for many entities or industries. And every time I tried to take these tools to these entities or industries, I got resistance.

I found that the path past that resistance in almost every single instance has been the idea that these tools should be co-developed, that the stakeholders should be involved in the development process through the development process.

And also, the second piece has been educational partnerships, where folks are brought together and brought along. Perhaps that could be one of the ways in which we could encourage industry, academia, and the Coast Guard to work together to really understand what the key issues are, the barriers are that are preventing adoption, and work our way past those together.

Mr. GARAMENDI. Admiral?

Admiral WHITE. I said a lot already. I will just say that the Coast Guard has been successful many years in innovating. Look at the work they have done at the Joint Interagency Task Force, in combating a lot of transnational criminal activities through intelligence, surveillance, and reconnaissance. Look at the work they have done against illegal fishing activities such as high seas drift nets, going back—more modern entities, as well.

The Coast Guard can and does innovate. I still get back to I think in many ways it is a problem of resources, and that you have

got to invest the resources upfront in the longer term—rapid transition of the tech that is out there. But I know we all believe it is something that has to be done, so I think we need to look hard at the resources that are available to the Coast Guard to work in partnership with the Navy and the others to address these gaps, sir.

Mr. GARAMENDI. It would be a serious error for me to try to sum up all that you said, but it seems to me that there are a couple of things here.

First of all, the culture of the Coast Guard: Take care of today's problem, operational words that are used. That, I think, goes to the incentives of the—if promotion included innovation, the innovation of an officer or of a—any individual of the 42,000, if their promotion also included their interest in innovation and bringing innovation online, so now you build a different cultural attitude.

Secondly, the resource, which is a problem that the Coast Guard does have to deal with. I guess we have to deal with it. And we noted the 47-percent reduction in the research technology.

And the third is interaction with other governmental agencies.

They seem to be the three lessons that I would draw from this.

Mr. Chairman, I will yield back.

Mr. HUNTER. I thank the ranking member. I would like to differentiate, too, between super high-tech stuff that is in its infancy stages and is nascent—and a floating surfboard that can sense if there is oil in the water that has been around for 5 years or longer—longer than that, actually, I just saw it 5 or 6 years ago. That's not rocket science.

And just in the same way, if you look at the southern border and you have a border fence now, you have basically an obstacle planted, what it has allowed the Border Patrol to do is spread their people out. Because there is a high-speed road and a fence. So if someone sees something, someone can get there in 1 minute on a quad. They can cover a mile in 30 seconds and they are there.

It is the same with the Coast Guard. I don't get the adapting of new things, when it is really just a surfboard that can cue you on a ship coming at 50 miles an hour, or a storm, or oil in the water. That is not rocket science, that is not crazy, and it is not even new any more. But when it takes the Coast Guard 5 years to put a loudspeaker on a small cutter, we are looking at decades before they will allow a surfboard with a sensor that costs $500,000.

It is not where I am talking big money, either. I am talking small money, in terms of being efficient and effective.

With that, Mr. Lowenthal, you are recognized for your questions.

Dr. LOWENTHAL. Thank you, Mr. Chair, and I want to thank the panelists for being here.

I just wanted to mention first—and then I will have some questions—that I represent the port area of Long Beach, California, which is right adjacent to L.A. And so I have had the good pleasure of visiting with the port pilots the CDIP [Coastal Data Information Program] buoy network in the San Pedro Bay. And I know the value of the information that these devices both collect to our ports' pilots, and to researchers, oceanographic researchers, and to the entire maritime community. And so every year I lead a letter in the Congress supporting robust appropriation for the CDIP program.

And also another program, which I am so impressed with also is one that I think Dr. Terrill at Scripps really led the effort, and that is the Under Keel Clearance Precision and Navigation Project. We have these huge tankers coming in and the ability to get in and out of our ports with very, very little clearance is so, so important. And it—really, the more we can do that, that reduces the inefficiency of offshore lightering, which is something we would like to eliminate, or do as—you know, as much as possible, because that just adds another step and another danger to the process.

But I want to get back to the testimony of Dr. Ozkan-Haller and all the others about partnerships across Government agencies. You all talked about, I think, academia, the private sector, how we need these robust initiatives connected across these multiple entities and geographic—I want to know, what can the Congress do about that? What do you think, if you were going to advise us to take some very concrete steps to promote the partnerships that you are talking about? Could you give us some—just dig a little deeper and give us some examples of what you would like us to do?

Dr. OZKAN-HALLER. Thank you very much for this excellent question.

Partnerships between Federal agencies are really key, and they are key not just for the problem that you just mentioned, but for a variety of other problems that are related to the coastal zone, be it, for instance, coastal flooding due to storm events, or be it energy production from waves or tidal currents across the coastal zone.

I think, you know, I have always felt that I have been very fortunate to work in a field where there are multiple Federal agencies interested in funding research and development. That is great, you can really expand your portfolio. But at the same time, sometimes certain tasks fall through the cracks, where no one agency feels—especially mission agencies—feel like it falls squarely within their purview to get something done.

And sometimes some of the supplied work that we have been talking about, some of this transitioning the research into the hands of the folks who would actually use it, tends to fall through the cracks. This is one of the reasons why I wanted to stress how important it is to make the strategic investment in the technology development piece, in the actual transition, that last missing link to really make it easy for folks on the ground to utilize these.

Admiral White mentioned the National Oceanographic Partnership Program. I am part of the Ocean Studies Board of the National Academies. And as part of that we talk about that program a lot as a potential conduit for getting agencies to work together. There has been some resistance in doing so, partially, I think, because of who is in the leadership position of the NOPP program at any given time.

I have been told there are only two ways to get agencies to work together, and you all can tell me if this is correct or not. One is they are all buddies and friends and they get along, and so therefore they work together anyway. Or otherwise, they have to be told from above to work together. So maybe that is a place where this committee can come in.

Thanks for the opportunity——

Dr. LOWENTHAL. So we are good at—we are the tellers.

[Laughter.]

Dr. LOWENTHAL. Anybody else want to add something to that, in terms of how we create or, really, the role that the Congress should play in fostering and promoting partnerships, especially across Federal agencies?

Yes, Admiral White.

Admiral WHITE. Thank you, sir. I should mention that there has been a piece of legislation that has been entered into the process, I believe, by Congressman Panetta and Congressman Palazzo called Commercial Engagement Through Ocean Technology Act of 2018. It's CENOTE, by short. This is an act that is meant to basically make NOAA work more closely with Navy to test and develop autonomous vehicles and other blue tech that we have talked about today.

The Coast Guard was not called out in that specific piece of legislation right now. But that type of legislation, I would encourage you to take a look at it. Is it something that you might want to look at with the Coast Guard? And—but those type of vehicles——

Dr. LOWENTHAL. That would be one of the vehicles that you are talking about that would foster that kind of relationship between NOAA and the other agencies?

Admiral WHITE. Yes, sir. It would be a teller type of role that you would be playing.

The same with NOPP [National Oceanographic Partnership Program]—by the way, which again is an act from the year of 1996, enrolled in the 1997 NDAA [National Defense Authorization Act]. But, you know, could use probably a fresh look and some fresh telling, as well.

Dr. LOWENTHAL. Thank you.

Yes, Mr. Jones?

Mr. JONES. I assume that you are involved, as you are naming new Commandants and people like that. And to the extent that you ask questions about innovation and technology, I think that is very telling, particularly for younger officers as they are coming up, that they see that that is an area of particular interest.

And I would like to just note that the new Vice Commandant, Charlie Ray, did come down, and we put on an event for him. I think we had 10 companies present. He said he'd never done that before, and he was fabulous. Not only did he make a lot of companies really feel good that he wanted to be open, he brought people with him that followed up. And that kind of regional interface, the ability to talk to industry, to know that leadership is interested—again, thinking of these innovation councils going on a regional basis—I think could have a lot of benefit. Also, younger officers can get involved.

So I think that things can be done without great cost that can really help change, but particularly, when you make that an issue at approval levels, the highest levels.

Dr. LOWENTHAL. Thank you.

Thank you, Mr. Chair. I yield back.

Mr. HUNTER. I thank the gentleman. I want to ask a really quick question before we go to Ms. Plaskett.

Is there a kind of symposium that the Coast Guard has every year? The Army has a big AUSA [Association of the United States

Army] convention, where every tactical killing thing known to mankind is there at the convention center here. The Marine Corps does the same thing. The Air Force has a Big Safari, the Navy has got a big symposium. Have any of you been invited to the Coast Guard technology symposiums on stuff that is out there?

Mr. JONES. So I am told the last one was 5 or 6 years ago.

Mr. HUNTER. That is good. Nothing has happened since then?

Mr. JONES. I am sorry?

Mr. HUNTER. Nothing has happened, technologically in 5 or 6 years, so that is understandable.

Mr. JONES. I have a feeling it was probably cost-driven. But they had contracted with NDIA to do an innovation forum.

And I think one other way to address that, rather than putting on their own forum, let's say in Washington, DC, a lot of the smaller companies don't necessarily know about it. And maybe the way to address it is to have officers go to tech forums in parts of the United States. So it reduces their cost, and they can go to where technologies already are being shown.

Mr. HUNTER. Yes, Doctor?

Dr. OZKAN-HALLER. I would also argue that certainly the local Coast Guard officers that are within my area, the mouth of the Columbia River and other treacherous inlets in the Pacific Northwest, do interact with companies, as well as with academic institutions, but at a much more local scale than what you are referring to. But those interactions, clearly, I think, are also useful.

Mr. HUNTER. And there is a different dynamic, too. Because if you are in San Diego and you make a new thing for the Marines, you can go to Camp Pendleton, give a regiment or battalion that is deploying the gear, they can go to play with it and actually test it, do operational testing, and come back. The Coast Guard cannot do that. They don't have the rules and regulations set up.

So even from my loudspeaker example, the LRAD, they had to go up all the way through, I think, at the admiral level or the captain level in the Coast Guard to be able to put that on a small cutter in San Diego in order to test it. It wasn't just a thing that the local commander there could say, "Hey, guys, we are going to test a loudspeaker," pop it on one of the cutters. They had to get a person who specializes in that, who was already doing it in Florida, and then took that—it is just not as—it is not easy at all, actually, at the local level or at the small unit leader level.

Ms. Plaskett, you are recognized.

Ms. PLASKETT. [No response.]

Mr. HUNTER. Ms. Plaskett, you are recognized.

Ms. PLASKETT. Yes, thank you very much.

Mr. Chance, I wanted to ask you a question. You all were at the first panel and the discussion that was had at that time. I had a discussion with the testifier then about the use of technology with the Coast Guard in terms of interdictions on drugs and weapons. He talked quite a bit about unmanned aerial systems and their relationship with other law enforcement entities.

What would be the use and the efficacy of using UUVs, as well as USVs in this area? Is that a possibility?

Mr. CHANCE. Sure. USVs, which is my area of expertise, I can tell you would lend itself tremendously.

For example, we are now converting a 38-foot patrol craft, optionally unmanned, that can stay and loiter offshore for weeks at a time, running a radar, looking for vessels that need to be investigated. So this vessel and the data on board would be monitored back at a control center on shore, or even on a Coast Guard cutter.

And so, if the Coast Guard decides that they want to investigate, they can dispatch that vessel out and be able to interrogate it via the satellite base, through the link to the VHF radio, and actually talk to that vessel. Or if they can't communicate that way, through a hailer and then over the satellite link. And if necessary, they can even, as I mentioned in my testimony, deploy a net system that entangles in the prop that will stop that vessel until the Coast Guard can reach them and investigate that situation.

Ms. PLASKETT. Interesting, really great. Thank you.

I had a second question for Admiral White. This was with regard to the investment that is being made. Do you happen to have any statistics or information that speaks to the amount of venture capital that is being invested in the types of technology that you discussed, and various blue technology and its growth?

Admiral WHITE. I don't have those at my fingertips, ma'am, I apologize. But I will get an analysis of that for you and get it back to you.

Ms. PLASKETT. Would you say that the magnitude of that is how much less that is than space or other areas or—what are the ways that we can get VC funding into this area?

Admiral WHITE. I will go back to the comments by one of my cohorts on this panel, is that I think that it is absolutely—there is an order of magnitude difference in the investment that we are making in exploring space and trying to understand what is going on in oceans on planets that we will never live on—for many generations, at least—whereas we need to pay more attention to our own ocean and our own interspace that we have here. It is an order of magnitude difference——

Ms. PLASKETT. Is——

Admiral WHITE [continuing]. In terms of technology——

Ms. PLASKETT. Is there a role that Congress can play in incentivizing or getting the private sector and these venture capital groups, private equity groups, to be engaged in this?

Admiral WHITE. I think working across the various committees between your committee, looking at the science committee, all the actual committees, and focusing and really trying to balance what is really important to our population right now. And the maritime and maritime transportation, maritime safety and security environment has to be paramount for the reasons that we have all talked about. And I just believe you can help elevate sort of the understanding, not just by the folks here in DC, but by our population, writ large.

We all love space. We all want to be Captain Kirk, which means it is either our Navy or our Coast Guard——

Ms. PLASKETT. Or Uhura.

[Laughter.]

Admiral WHITE. Even better. But as we do that, we need to understand that it is a change in perception of that. It is a level of importance. And that is through ocean literacy, and ocean under-

standing, and the STEM, ocean STEM that I talked about, which would drive education of the next generation of our maritime Nation. We should be vested in ocean STEM as a mandate to drive this type of discourse going forward, ma'am. Thank you for the question.

[RADM Jonathan White provided post-hearing supplemental information to his remarks to Delegate Stacey E. Plaskett below:]

VENTURE CAPITAL INVESTMENT IN SPACE

$18.4 billion in private money (e.g., seed money, prize money, venture capital, private equity, etc.) has been invested in the space industry since 2000. From 100 in 2011 to more than 1,000 in 2016, the number of space companies has grown exponentially. To date, 2015 has been the largest venture capital (VC) investment year at $1.891 billion (more than all previous years combined) from 50 VC firms. The bulk of this money came from Google's $1 billion investment in SpaceX. 2017 was not far off that record with $1.596 billion in VC investments from 87 VC firms (up from 44 in 2016). As of 2017, more than 250 VC firms had invested in space activities with 16 making repeat investments.

Experts report that investors see dual function in the technology they are supporting (e.g., satellite imagery data management can serve industries beyond space) and believe this has been a key driver for investments.

VENTURE CAPITAL INVESTMENT IN OCEANS

Tracking private investments in startup companies and technology is very difficult unless the transactions are made public or specific industry-titled venture capital funds are created. Venture capital funds are investment funds that manage the money of investors who seek private equity stakes in small- to medium-sized companies and startups. To date, the U.S. does not have any blue technology or blue economy VC funds. Additionally, due to the lack of funds, there are no robust efforts to track this information like there are for space. Any VC investments in blue technology to date have occurred through nonspecific VC funds or individual investments.

Experts in marine technology recognize the need to establish a designated fund to drive (and monitor) investments and are working towards this goal. In 2017, an important first step was taken by forming the global BlueTech Cluster Alliance coalition. By bringing blue tech companies together, investors can easily and efficiently see the breadth of technology available and how it works together. This partnership also allows the ability to leverage expertise and share financial investments, including international money to foster growth in the maritime domain.

WHAT ARE OTHER NATIONS DOING?

Other nations are advancing rapidly. China, Singapore, and the United Kingdom are already identifying gaps and are making substantial federal investments in basic research, technology development, education programs, and workforce training. In January 2018, the National Science Foundation (NSF) reported that for the first time, China produced more scientific publications than the U.S. As a metric for discovery and advancement, this is a concerning data point showing our Nation faltering in global science primacy.

Additionally, confidence in China's science and technology innovation was evident with $10.7 billion from VC investments in the second quarter of 2017. While the value is lower than investments in U.S. technology ($18.7 billion during the same time), it shows a dramatic increase (214 percent) from 2013 when less than $5 billion was invested for the entire year.

In the blue technology sector, seven nations are called out as leaders in ocean innovation; they are members of the global consortium BlueTech Cluster Alliance (BTCA):

- Portugal (Forum Oceano)

- Ireland (Marine Institute)
- Canada (Oceans Advance)
- Spain (PLOCAN)
- France (Pole Mer Mediterranee)
- U.S. (The Maritime Alliance)
- U.K. (U.K. Blue Growth Network)

Additionally, all of these nations except the U.S. are members of the United Nations Convention on the Law of the Sea, giving them a leg up on unity when considering partnerships and combined initiatives.

WHAT CONGRESS CAN DO

Elevate the visibility of and investment in marine technologies through various legislative tools, including appropriations, authorizations, hearings, and briefings. Look for nontraditional legislative vehicles to address the issue.

Through reauthorization of the National Ocean Partnership Program (NOPP) Act of 1996, specifically task the NOPP agencies to analyze and track U.S. VC investments on blue technology.

Ms. PLASKETT. Thank you. And that actually leads to the second question I had. And we talked about the private sector. I wanted to talk about education.

The Virgin Islands has one of the premier maritime or marine biology programs. But in other areas related to ocean STEM, I think that there is a dearth of degree options of areas that young people can go into.

Particularly, my question was, are there ways that we have tried to increase communities of color, or other minorities—African American, people of color, Latinos—in this area?

And what are the ways that we can drive interest for individuals who live on the coast, communities of color that are tremendously affected by food insecurities, climate change, that is affected by the oceans? Does anyone on the panel have any thoughts? Please.

Mr. JONES. First, to your first question, there is not one blue tech investment fund in the United States today. There is not one. There are a number of people focused on space, but there is not one venture fund in the United States that is really focused on blue tech.

We are doing our third year, part of Blue Tech Week, a Blue Tech Pitchfest, and we are reaching out around the United States. So I think there are roles for the SBA and other agencies—could try and help make—fund organizations that would invest in blue tech companies.

Related to education, we, this year have a major effort in particular to reach out to underserved communities. In a place like San Diego, where the cost of housing is very high, it is very hard to bring somebody in and—technical workers. So we believe that we are going to have to grow our own entrepreneurs and our own technical workers.

So we have started an internship program with heavy emphasis on underserved communities. We got some funding from our—a local foundation. We have just started an immersion program. It will be a pilot program. This year we will do 2 weeks.

We also started a blue STEM—we used to call it ocean STEM, but we want to be more comprehensive than that, so we are talking blue STEM—with the San Diego Unified School District. We have

picked a middle school and a high school. We are creating an academy and a workforce pathway. We are working with our workforce development agency, with all of our universities to really start at the earliest levels. And once we can create a replicable model, we plan to put it all across San Diego County and then across the country.

So it is something that we are spending a lot of time on, is this whole component of education. We know it is critically important to bring females and other underserved communities into this.

Ms. PLASKETT. Mr. Coyle?

Mr. COYLE. Can I get back to your investment question? I think there are—as Mr. Jones mentioned about there is no blue tech fund, I think that is one avenue, in terms of—whether it is sovereign wealth management, asset management, private equity, venture capital, there is huge opportunity on that. I was just at a conference in Santa Monica about what is being done in that regard in the Middle East.

I was just at a conference 2 weeks ago at Yale University on the impact investment side, which is looking at how do you make profit and do good in the same equation. And if you look at the chairman of BlackRock, I think, sending these CEOs letters about maybe a month ago that their portfolio companies not only have to make profit, but actually have to make an impact, that is fundamental.

When you have got one of the biggest asset management companies in the world, you have got the investment community—there were plenty of Wall Streeters that were there, banks that are now fundamentally looking at this as—not as just donating to a nonprofit—as how do we use technology to return profit and make societal difference? That is fundamental. That's not happened in the investment community.

And so I think there is a role that Government can play incentivizing the investment community to pay more attention to emerging blue technology.

Ms. PLASKETT. OK. Yes?

Admiral WHITE. For 21 years there has been the National Ocean Sciences Bowl, started by Admiral Watkins again. It is a high school ocean quiz bowl competition. It brings together multiregions across States and around the country, not just coastal, but Idaho and Colorado. And this is a high school quiz bowl that, unfortunately, is not being utilized to its full potential today. It was meant to—actually designed to be run by a combination of resources from multiple Federal ocean agencies under the NOPP Act, originally.

This is an opportunity to work with aquariums in inner cities and underrepresented populations, to grow not just at the high school, but even the middle school level, and really use the ocean. Because the aquariums and parks—ocean attracts people. They want to engage in understanding it. We have a great opportunity through this program and other programs being run through the education partnerships and through other agencies.

Not enough attention is being paid to this, in my opinion, writ large, and it would be a great opportunity to ask some hard questions of the agency. You have got tools out there. Why are you not utilizing them to their fullest potential?

[RADM Jonathan White provided post-hearing supplemental information to his remarks to Delegate Stacey E. Plaskett below:]

IMPORTANCE OF STEM EDUCATION

Good information enables well-founded decisions. Having a foundation in STEM education can make life easier, from understanding mortgage payments and computer basics to natural processes like erosion and weather. A society that understands how physical parameters contribute to climate and natural hazards can make better informed decisions when building homes or preparing for storms. To remain a leader in science and innovation it is critical to educate the next experts in ocean science and STEM.

When looking at science course availability, fewer than 50 percent of high schools offer education in Earth or environmental science.

- 98 percent offer biology
- 94 percent offer chemistry
- 85 percent offer physics
- 48 percent offer environmental science or ecology
- 48 percent offer Earth or space science
- 24 percent offer engineering

These subjects can help make complex concepts easier to comprehend because they provide real-world examples across multiple disciplines (e.g., physics, geology, physiology, chemistry, biology).

U.S. STEM and geoscience jobs are projected to grow by 12.5 and 14 percent respectively from 2012–2022. In 2016 there were 26 million STEM related jobs, but in some disciplines the workforce is aging rapidly (47 percent of American geoscientists in the private sector and 43 percent in the Federal Government were over the age of 55 in 2016). We're looking at a cliff in geoscience workforce. Additionally, the blue economy is projected to double by 2030 to over $3 trillion and 40 million jobs. These jobs demand an ocean-STEM educated workforce and that must start during primary education.

DIVERSITY IN STEM AND O–STEM

A 2018 survey reported, Hispanics and blacks comprise 16 and 11 percent of the U.S. job market respectively, and when looking at STEM careers their representation is much lower (e.g., life science 7 and 4 percent, engineers 8 and 5 percent, physical scientists 7 and 6 percent, respectively). The survey asked why Hispanics and blacks are not working in STEM, and the top reported reasons were: limited access to quality STEM education (42 percent), not encouraged to pursue STEM at a young age (41 percent), and don't believe they can succeed in a STEM career (33 percent). If you examine ocean sciences (graduate students awarded master's degrees) a greater lack of diversity is observed, with Hispanics, blacks, and multirace individuals making up 4, 1, and 2 percent of the degrees awarded.

However, underrepresentation goes beyond race, including gender and financial disparity. The 2018 study showed 69 percent of individuals with non-STEM careers were interested in a STEM career during high school and college and the main reason they chose not to pursue the field was due to cost and time barriers.

HOW DO WE CULTIVATE THE DIVERSE AND INNOVATIVE FUTURE OF STEM?

Since most high school curricula don't include oceanography, informal educational programs like the National Ocean Sciences Bowl (NOSB) or community initiatives like Pop-Up/Drill-Down Science are increasingly important to introduce students to (and get them excited about) ocean science and blue technology.

The 21-year-old NOSB promotes collaboration, teamwork, innovation, critical thinking, and professional development, all valuable skills for the O–STEM workforce. Specifically, 2,000 participants annually from across the Nation, including Alaska, Hawaii, and noncoastal regions. From 2004–2010, funding was used to increase diversity, specifically targeting minorities and underserved communities. The pilot program highlighted minority and

underrepresented students' interest in ocean science and NOSB; students lose interest when programs and access are not stable. With concerted efforts and dedicated funding, diversity was nearly doubled. In fact, the 2018 competition year had a participant makeup of 50 percent female, 34 percent non-Caucasian and 66 percent Caucasian (averaged 37 percent non-Caucasian and 63 percent Caucasian over the last 5 years).

Pop-Up/Drill-Down Science is a 5-year pilot program specifically designed to expose communities, across age ranges, to Earth and ocean sciences through an immersive "pop-up" exhibit entitled In Search of Earth's Secrets. The exhibit debuted in March 2018 with the following goals:

- Increase access to and awareness of ocean and Earth science and careers, especially in disadvantaged communities, by bringing the exhibit and associated activities and scientists themselves to nontraditional venues ranging from block parties, local festivals, malls and parking lots to libraries, museums, and science centers
- Create a sustainable model for STEM learning in informal environments
- Increase interest in the scientific drilling and research activities of the International Ocean Discovery Program among the general public (children, teens, and adults) who attend the Pop-Up/Drill Down Science events
- Foster partnerships between educators and scientists that lead to broader dissemination of scientists' research and the larger vision of NSF

Programs like the National Ocean Sciences Bowl and Pop-Up/Drill-Down Science are essential for many underserved communities because it might be the only way they are getting exposure to and knowledge about the ocean.

Ms. PLASKETT. Thank you.

Thank you so much for giving me the opportunity to ask these questions.

And Mr. Jones, I think that the island of St. John, where we are actually about to rebuild our school, would be a great place for you to try another pilot out for these young people.

So thank you, Mr. Chairman, and I yield back.

Mr. HUNTER. I thank the gentlelady. If there is no further questions, I thank all the witnesses for their testimony and the Members for their participation.

The subcommittee is adjourned.

[Whereupon, at 12:03 p.m., the subcommittee was adjourned.]

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TESTIMONY OF
REAR ADMIRAL MICHAEL J. HAYCOCK

ON
"COAST GUARD – BLUE TECHNOLOGY"

BEFORE THE
HOUSE COAST GUARD & MARITIME TRANSPORTATION SUBCOMMITTEE

MAY 8, 2018

Introduction

Good morning Mr. Chairman and distinguished Members of the Committee. It is my pleasure to be here today to discuss the Coast Guard's efforts to pursue technologies and solutions that have the greatest potential to enhance the service's acquisition and mission execution.

The Coast Guard is very thankful for this Committee's enduring support of our acquisition, construction and improvement programs, particularly in fiscal year 2018. This support is critical to the Service's efforts to recapitalize its aging fleet of cutters, aircraft, boats and support systems, and to address a growing backlog of shore construction and facility needs. Coupled with the supplemental funding for hurricane response activities, your legislative actions have enhanced our ability to prepare for and respond to mission needs, including future disasters.

The U.S. Coast Guard is the world's premier military, multi-mission, maritime service responsible for the safety, security and stewardship of U.S. waters and hundreds of miles seaward. At all times, a military service and branch of the U.S. Armed Forces, a federal law enforcement agency, a regulatory body, a first responder, and a member of the U.S. Intelligence Community, the Coast Guard stands the watch and serves a nation whose economic prosperity and national security are inextricably linked to broad maritime interests.

The Coast Guard's breadth of missions, competencies, and authorities create unique research opportunities and challenges. The Coast Guard's Research, Development, Test, and Evaluation (RDT&E) program supports research and innovation across all of our mission areas, including search and rescue, drug and migrant interdiction, oil spill and natural disaster response, commercial vessel inspections, maritime cybersecurity, and many others.

Coast Guard Research, Development, Test, and Evaluation Program

This year marks the RDT&E program's 50-year anniversary. The office was established in 1968, followed by the creation of our Research and Development Center (R&D) Center in New London, CT, four years later. Since that time, the Coast Guard RDT&E program has developed an impressive resume of nearly 2000 products, from studies to prototypes, which have enhanced Coast Guard missions and informed Coast Guard leadership decision-making.

At any given time, the Coast Guard RDT&E Program is working on more than 70 projects in support of Coast Guard operators. The RDT&E program focuses on applied technologies and enhances mission execution by facilitating the transition of new or existing technologies into the service's operational forces, while also providing Coast Guard leadership with knowledge necessary for making strategic decisions. The RDT&E program includes the Coast Guard Innovation Program, developed to best harness the creativity of the Coast Guard workforce to address enterprise challenges.

Cooperative Research and Development

The Coast Guard RDT&E program partners closely with Department of Homeland Security and Department of Defense research entities, national laboratories, academia, and industry to leverage vital lower Technical Readiness Level or "TRL" research. Coast Guard RDT&E recently teamed with the DHS Office of Science and Technology (DHS S&T) to form the CG/DHS S&T Innovation Center (CG-STIC). CG-STIC is focused on projects intended to rapidly move high-TRL technologies into the hands of operators.

With a finite research budget to address a broad mission spectrum, finding willing partners is especially important. Coast Guard RDT&E's list of partners and partnership agreements is wide-ranging and is perhaps best exemplified through how Coast Guard RDT&E has worked with DHS S&T Office of University Programs at institutions across the nation. These efforts include work with the University of Southern California to inform policy decisions on maritime cybersecurity, as well as the University of Alaska to identify Arctic technology priorities. Coast Guard researchers also work alongside the Bureau of Safety and Environmental Enforcement (BSSE), the Naval Research Laboratory, and the Department of Energy at our nation's only facility for maritime full-scale in-situ oil burn research, the Joint Maritime Test Facility (JMTF) in Mobile, Alabama.

While academic institutions are a vital resource for research, the Coast Guard also focuses on building partnerships with industry. Coast Guard RDT&E maintains a dozen Cooperative Research and Development Agreements (CRADAs) with industry firms. CRADAs are mutually beneficial; they provide industry direct access to understanding end-user needs, while keeping the Coast Guard abreast of the latest developments in private-sector technology. As an example, the Coast Guard collaborated with Mercury Marine to explore diesel outboard technology. The project allowed Mercury to refine their product based on real-world operations, and helped the Coast Guard explore moving toward a single-fuel surface fleet. Coast Guard RDT&E currently has active CRADAs with Lockheed Martin, Conoco Philips, and many others.

In addition, the R&D Center partners with DHS S&T to introduce technology solutions into Coast Guard operations through DHS prize competitions. Leveraging innovative approaches like the prize authority allows the Coast Guard to crowd-source good ideas from the public to help address operational challenges.

Transitioning Research & Development: Supporting Future Operations Today

The Coast Guard's research project portfolio is closely tied to service mission needs. Coast Guard RDT&E uses its innovation crowdsourcing platform to collect project ideas from the entire workforce. This raw list of ideas is prioritized by program managers, operational commanders, and other subject matter experts throughout the service. Potential projects are vetted by Coast Guard senior leaders and prioritized to ensure alignment with service priorities.

RDT&E program research generally focuses on higher TRL applied research, to concentrate efforts on how to adapt proven technologies to enhance Coast Guard missions. Evaluation of high-TRL technology often includes testing commercial off-the-shelf products in actual Coast Guard operating environments.

Over the years, Coast Guard RDT&E products have provided vital support to operational commanders. In the 1970s, the program developed "oil fingerprinting" to help Captains of the Port identify oil spill responsible parties. In the 1980s, the program helped develop navigation technologies, such as differential GPS, that were crucial to modern international commerce and mariner safety.

Today, RDT&E is working on a full spectrum of unmanned and counter-unmanned systems. Current projects include various unmanned and autonomous platforms (subsurface, surface, air, and space) and their advanced sensors capabilities, as well as systems to counter threats from unmanned aerial platforms. The program has developed and tested non-lethal munitions, technology to identify hoax search and rescue callers, and continues to lead national research focusing on oil spill mitigation.

The RDT&E program is agile, and capable of responding quickly to mission need. After the recent loss of the *SS El Faro*, Coast Guard RDT&E aided the investigation by testing the flotation of survival suits similar in age and type to those carried aboard the ship. The program supported several recent project ideas, related to operator requirements identified during the active 2017 hurricane season. Responders requested evaluation of asset tracking capabilities, social media distress notifications, and other issues that arose during the storm response. RDT&E work is now underway in these areas to help enhance first responder safety and mission performance.

The Coast Guard RDT&E program endeavors to respond to emergent needs, while also helping Coast Guard leadership position our service for the future. Coast Guard RDT&E has also begun exploring machine learning, cubesats, augmented reality, and other emergent technologies. With the help of Congress and this Subcommittee, the program is now evaluating unmanned aircraft systems, low-cost maritime domain awareness, and research important to the development of the Coast Guard's future fleet of icebreakers.

Maturing the Program and Future Direction

As the pace of cultural and technological change accelerates, so too do threats and opportunities in the maritime domain. The Coast Guard RDT&E program is increasingly vital for developing and assessing technologies and policies for future missions. The increasing intensity of natural and manmade disasters require the Coast Guard to continually find better ways to mobilize, communicate, and coordinate among responding agencies and volunteers.

Autonomous ships, and the growing operational complexity in our nation's ports and waterways, will challenge traditional approaches to maritime governance and risk mitigation. Increasing human activity in the Artic will likely strengthen the demand for Coast Guard presence in this extreme operating domain. Coast Guard RDT&E will continue to provide knowledge and tools to manage risk in these areas.

The Coast Guard RDT&E program faces some of the same challenges as other government agencies in attracting and retaining subject matter experts needed to understand and leverage technology in areas such as cybersecurity and artificial intelligence. Many professional scientists and engineers in government service are retirement-eligible, and the RDT&E program is exploring opportunities to better develop a pipeline of subject matter expertise able to address the research needs of the future.

Conclusion

Over the last 50 years, the Coast Guard RDT&E program has helped make our nation more resilient by improving the Service's response to disasters and emerging mission demands. The Coast Guard's breadth of missions and authorities requires a robust RDT&E program to ensure we are always ready to face the threats of tomorrow.

Thank you for the opportunity to testify before you today and for your ongoing support of the women and men of the Coast Guard. I look forward to your questions.

WRITTEN TESTIMONY OF

Dr. Eric Terrill
Director, Coastal Observing Research and Development Center
Scripps Institution of Oceanography
University of California San Diego

**BEFORE THE UNITED STATES HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION**

BLUE TECHNOLOGIES: USE OF NEW MARITIME TECHNOLOGIES TO IMPROVE EFFICIENCY AND MISSION PERFORMANCE

May 8, 2018
Washington, D.C.

Introduction

Chairman Hunter, Ranking Member Garamendi, and members of the Subcommittee, thank you for the opportunity to be here today to discuss new maritime technologies. My name is Eric Terrill and I am the Director of the Coastal Observing Research and Development Center (CORDC) at University of California San Diego's Scripps Institution of Oceanography (Scripps), where I also received a Ph.D. in Physical Oceanography-Applied Ocean Sciences. I have 25 years' experience as an oceanographer leading basic and applied research programs around the globe. We partner with a number of federal and state agencies in our efforts to support national science and technical needs to sense and improve our understanding of the maritime environment.

A better part of my career has been dedicated to the field of ocean observing, environmental sensing, marine technology, and maritime domain awareness. I established CORDC as a research and development center within Scripps Marine Physical Laboratory, one of four original Navy-University applied Research Laboratories established in World War II in response to the need for academic innovation to support national security. Engineers, data analysts, and ocean scientists serve as an interface between Navy Research Development Test and Evaluation (RDT&E), Department of Defense operational commands, mission-driven commands, and agencies such as the U.S. Army Corp of Engineers and the National Oceanic and Atmospheric Agency (NOAA). I also have extensive experience working with industry to develop, improve, and evaluate new ocean technologies and unmanned platforms; the key subject matter of this testimony. I have served on transition and government review teams and Federal Advisory committees including a FACA oversight committee for the Integrated Ocean Observing System (IOOS). I presently serve on a Maritime Domain Awareness (MDA) working group sponsored by U.S. Pacific Command (PACOM) to develop MDA solutions for small island nations in the western Pacific including the Republic of Palau and the Federated States of Micronesia. Lastly, I co-founded Project Recover, a private-public collaborative, which conducts global searches using Unmanned Underwater Vehicles (UUVs) and DoD methodologies to locate WWII-era aircraft crash sites - to date

locations of 22 aircraft associated with 60+ MIA have been documented and reported to the Defense POW/MIA Accounting Agency.

I had the opportunity to review the Government Accountability Office report 18-13 on Coast Guard: Actions Needed to Enhance Performance Information Transparency and Monitoring, as well as the Coast Guard Reauthorization Act of 2017 legislation and will address some of these recommendations in my testimony.

Because many Scripps scientists and students are involved in maritime technologies, I sought input for my testimony from experts at Scripps. Aspects of my testimony on the specifics of technologies and data management are drawn from these colleagues. Some of these programs and labs may be familiar from my past testimony to this Subcommittee in 2013 on Maritime Domain Awareness. I will again provide background information for these programs, but the technologies discussed are either new and emerging or have a different application for USCG missions to aid in efficiencies. My testimony is organized as follows: 1. Samples of historic and ongoing ocean observation programs are provided as examples of the research community's role in blue technologies. 2. Unique partnerships to expand and leverage resource capabilities; and 3. Closing recommendations for action.

1. Scripps Research History Leads to Critical Ocean Technology Development

Scripps research areas of expertise relevant to the USCG mission include the mapping of ocean currents, mixing of ocean waters, Arctic prediction, sensor development, unmanned platforms, numerical ocean forecasting, maritime domain awareness including surveillance, and ocean waves. Scripps has technical expertise across all facets of marine technology, with some examples including sensor networks, data management and exploitation, unmanned underwater and surface vehicles, aerial drones, and airborne and satellite remote sensing. Founded in 1903, Scripps Institution of Oceanography became a part of the University of California in 1912. Scripps has a long history of supporting national defense objectives and has provided recommendations and technologies to "improve the efficiency, safety and security of maritime transportation" with a focus on the "better use and integration of maritime domain awareness data."

During World War II, Scripps oceanographers worked closely with the Navy to create surf and swell forecasts for successful Allied landings in North Africa, the Pacific, and the beaches of Normandy. Just as important, Scripps educated active duty weather officers so they could apply this new forecasting science on a daily basis to plan operations.

In 1975, Scripps researchers launched the Coastal Data Information Program (CDIP), a program that measures, models, forecasts and publicly disseminates real-time coastal wave information, and that now includes a network of over 70 wave buoys in 22 states and island territories. The conditions at the ocean surface impact all at-sea operations, and the data are critical for the operational maritime community to ensure safe and efficient navigation for military, commercial, and recreational maritime traffic, search and rescue efforts, and are relied upon by dredging project managers for safe operations.

In 1998, Scripps led the development of the revolutionary array of ocean monitoring sensors known as the Argo network. Launched in 2000, the Argo program now deploys a global array of

more than 3,800 free drifting profiling floats to gather subsurface ocean data. Combined with satellite observations, these data make it possible to operate global and regional ocean analysis models similar to those for weather forecasting in the atmosphere. They provide enormous amounts of new information on the ocean's changing state at weekly to seasonal to year-to-year timescales. These observations are critical for accurate model analyses that forecast the state of the interior of the ocean, and its fluctuation with a changing climate.

An existing framework that connects local stakeholders to readily accessible ocean information is accomplished through a network of regionally operated ocean observing systems that feeds data to a federal backbone. This system is the Integrated Ocean Observing System (IOOS), initiated 18 years ago at an interagency planning office (Ocean.US) that has evolved to being managed from a formal program office within NOAA. IOOS consists of eleven Regional Associations who operate local ocean measurement platforms, generate tailored products, and connect data to a federal data backbone that is supported by a set of standards. IOOS has shared many successes including providing on-scene environmental information to many of the extreme events that the country has been faced with (tracking pollution at the Tijuana Estuary, 2017 Hurricanes Harvey, Irma, and Maria, countless Northeasters, the Refugio oil spill in Santa Barbara, and Deep Water Horizon Oil Spill in Gulf of Mexico to name a few). As a decision support system, IOOS observations provides many of the 'behind-the-scenes' environment data that is leveraged for day to day decision making.

2. Leveraging Existing Resources Key for Successful Implementation of Unmanned Systems

In 2002, a Joint Harbor Operations Center (JHOC) was developed after the events of September 11, 2001. This center became a model for others to follow nationally and across the globe. In this center, Harbor Police Dispatchers work side-by-side with the United States Coast Guard, United States Navy, California National Guard, and Customs and Border Protection personnel. This system helps to facilitate information sharing, plus provides a fast and timely response to potential incidents to the Department's area of operations.

The San Diego JHOC is an incredible example of the Coast Guard and other enforcement agencies leveraging access to resources and data that could serve as a model for other Coast Guard and Maritime Transportation authorities. This type of interagency partnering is required if there is an expectation to field modern blue technologies to operational agencies for a common maritime maritime domain picture in support of Homeland Security. JHOC demonstrates the value of establishing centers for communities with maritime jurisdiction to streamline collaborations and make processes more efficient, especially as the Coast Guard and Subcommittee consider expansion of implementing new technologies including unmanned platforms into operations.

Unmanned Underwater Vehicles (UUVs) or Autonomous Underwater Vehicles (AUVs) continue to develop as the frontier technology for subsurface exploration and sensing advances. These platforms have matured from developmental prototypes to operational tools as evidenced by Navy initiatives to integrate the platforms into fleet operations. Examples of the technologies include buoyancy driven gliders, such as the SPRAY system developed by Scripps for wide area environmental surveillance and propeller powered vehicles such as the REMUS (Remote Environmental Monitoring UnitS), originally designed by Woods Hole Oceanographic Institution

(WHOI) and now available commercially from Hydroid Inc. These platforms can carry specialized payloads to sense the ocean and are tailored for persistent observation of the ocean (gliders), or highly detailed surveys (propeller driven vehicles). Both vehicles can employ different payload packages, and a have been demonstrated to competently sense ocean currents, light transmission, temperatures, seabed topography, and seafloor imaging. These same sensors can assist the USCG in detecting and tracking oil spills of unknown origin, finding sunken wrecks, mapping bathymetry and hazards, and detecting illegal fishing activities. Sensors now exist to allow for direct measurement of suspended oil and petroleum byproducts.

Unlike ship-mounted sensors, propeller driven underwater vehicles have a distinct advantage to navigate a grid or terrains with consistent and thorough geo-positioned tracks. Scripps currently has been operating for over a dozen years and performs a variety of ocean sensing missions including mapping wastewater, river discharges, and mapping hazards, benthic habitats, and areas of archeological significance including sunken ships and missing aircraft that support the national mission of finding and returning MIA from past wars.

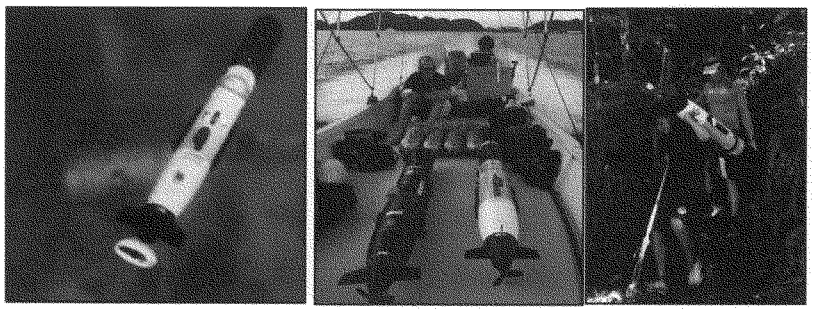

Figure 1. Left Panel: REMUS 100 passing over a sunken WWII aircraft; Center Panel: En route to a small boat deployment for two REMUS 100s and Right Panel: En route to a shore deployment of a REMUS 100.

Unmanned Surface Vessel (USVs): Scripps has several years' experience operating self-powered unmanned surface vessels called a Wave Glider; commercially available from the Boeing owned Liquid Robotics Company. A unique attribute of this system is the propulsion of the platform through harnessing the omnipresent ocean surface waves; allowing 100% of the power generated by the onboard solar panels for all electrical requirements. The system can carry onboard payloads as well as act as a gateway between underwater sensors and aerial assets including manned and unmanned aircraft. It can be used for a variety of applications that span basic scientific observation of the ocean to serving as a tactical communications platform filling capability gaps already identified by military users. Additional assessment capabilities for general Maritime Domain Awareness data needs, including payloads that allow for detection of small surface craft needs to be matured. The large footprint of the USV holds promise for supporting the launch and recovery of small aerial systems and deployment of ocean sensors. In my review of unmanned surface platforms, this one is the most mature and experienced at operating in a range of ocean environments. Capabilities in support of USCG include ship traffic monitoring, fisheries

protection, ocean sea state characterization, and monitoring of currents in support of oil spill trajectory analysis, communication gateways between surface craft, and ship routing.

Figure 2. Left. The submerged portion of the wave glider. Right. A wave glider recovery from a surface craft.

Unmanned Aerial Systems (UAS): Scripps has a long experience in developing, testing, or adapting technologies from other communities, and transitioning them into the maritime environment. Unmanned Aerial System (UAS) are no different, and Scripps scientists have led efforts to harden and adopt fixed wing and multi-rotor aircraft for use from research vessels. This same capability could be transitioned to USCG vessels. An emerging technology of interest are hybrid UAS that allow for vertical take off and landing (VTOL), but transit with a fixed wing; similar to an Osprey airplane.

Unmanned systems and data feeds can be of increasing use and benefit for Coast Guard to achieve its mission goals for surveillance, identifying aquatic invasive species in ballast water, identification of oil leaks and spills, tracking direction for oil spills, and other security operations in support of Illegal, Unreported, and Unregulated (IUU) fishing. As the Coast Guard and Congress work together on identifying resources to allow greater access to unmanned system technologies to help the Coast Guard meet its mission goals, mulit-agency partnership are recommended to allow for rapid communication of lessons learned and experience.

Tools needed for interfacing to data:

The Government Accountability Office report on the USCG implementation of the Common Operational Picture (COP) identified a number of concerns regarding data sharing and displays. The use of mapping overlays for data visualization can be extremely useful for displaying observations that assist in USCG missions such as search and rescue operations, marine safety and security, marine environmental protections, and ice operations. There is a wealth of direct observations and derived products that can be integrated into these systems including, but not limited to:

1.) Automatic Identification System (AIS)
2.) Bathymetry
3.) Navigational Charts
4.) Waves

5.) Surface and subsurface currents
6.) Satellite imagery
7.) Ice distribution

Many of these observations are available in a common data format that can be self-describing, machine-independent and delivered through a web service. Examples of these observations are found within the Integrated Ocean Observing System (IOOS) which, for many gridded products, utilize a Network Common Data Format (NetCDF) for file structure and are distributed via a Thematic Real-time Environmental Distributed Data Service (THREDDS). The Open Geospatial Consortium (OGC) provides recommendations and examples of data formats and services for data sharing and delivery. These technologies are developed and have proven examples for in-situ time series data (e.g. AIS, temperature, wind speed, salinity); gridded data and model output (e.g. HF radar derived service currents, waves, ice coverage); and imagery feeds (e.g. remotely sensed ocean color, pictures, charts). The data can also be displayed via open source – online platforms such as OpenLayers and Google Earth for unclassified interfaces or desktop applications such as TOPSIDE emerging from the Naval Undersea Warfare Center (NUWC) as a result of ONR-sponsored MDA and surveillance programs.

3. The Role for Technology Demonstrations, Technology Transitions, and Modular, Problem Driven Applications

A significant investment of time, funds, and process documentation is required for a full-scale analysis of developing technologies for USCG applications and implementation. Process studies through demonstration projects at established testbeds are one means to efficiently determine applicability and feasibility of new technologies. Scripps recommends developing partnerships with agencies within the Department of Defense that are already making investments in developing maritime surveillance systems. The Office of Naval Research (ONR) routinely conducts small-scale demonstrations to develop and test new concepts of operations and technologies, and leverages the expertise of their program managers in operating efficient Research, Development, Test, and Evaluation (RDT&E) initiatives. These science and technology investments have the ability to provide a low cost, flexible, and timely analysis of capabilities that can transition to operational users. Science and technology in a spiral development allows the capability to incrementally evolve and improve with lower risk. Successful demonstrations can be transitioned to support operations, while unsuccessful demonstrations provide valuable lessons learned and save significantly on a USCG-wide full-scale information technology guidance procedure.

For the last decade, ONR has made investments at Scripps and elsewhere, to develop, test, and evaluate new sensors and operation procedures for improving tactical ocean and atmospheric environmental information collection. One example of ocean technology development driven by emerging mission requirements is ONR's investment in autonomous vehicles. The employment of unmanned air, surface and subsurface platforms has transformed environmental sensing in the maritime environment. Unmanned platforms, outfitted with appropriate payloads, have conducted unprecedented open water autonomous missions and data collection in support of improving ocean forecasts. Through a robust communications architecture and data fusion software, in-situ collections are now available at time and space scales applicable to the investigation. The investment in maritime technologies and platforms has resulted in the development of tactics,

techniques and procedures that are applicable to today's discussion of Blue Technologies and the use of new maritime technologies to improve USCG efficiency and mission performance.

Demonstrations and Partnerships:

Scripps research helps identify threats, challenges, and risks in marine environmental management and conservation and surveillance and enforcement. Specifically, the technologies being developed and evaluated address the following issues:

- Ecosystem Based Management of the Large Marine Ecosystem
- Performance assessment and enforcement of local Marine Protected Areas
- IUU Fishing – industrialized
- Transshipment – Contraband
- Fishing Aggregation Devices (FADs)
- Poaching
- Human smuggling

The use of emerging technologies such as unmanned platforms and fusion of data from commercially available satellite data with in-situ sensors and numerical weather forecasts can assist in efficiently overcoming the tyranny of distance that is common with surveilling large maritime EEZ. The U.S. Exclusive Economic Zones (EEZ) is the largest in the world, spanning over 13,000 miles of coastline and containing 3.4 million square nautical miles of ocean - larger than the combined land area of all fifty states. Contained within our EEZ are Marine Protected Areas, where natural and/or cultural resources are given greater protection than the surrounding waters.

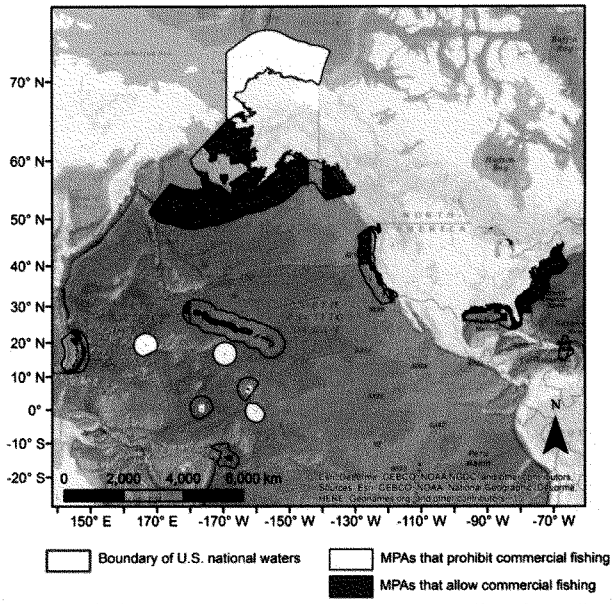

Figure 2. The U.S. Exclusive Economic Zone spans over 13,000 miles of coastline and covering 3.4 million square nautical miles of ocean. Contained within our EEZ are Marine Protected Areas.

The physical expanse of our EEZ and MPA creates a challenge for monitoring. Today, few data are collected and synthesized in a manner that allows for deterrence, detection, interdiction, and prosecution of illegal activities, including illegal, unreported, and unregulated (IUU) fishing; transshipment of contraband; and human trafficking or ecosystem-based management decisions. Data collected through deployment of new maritime sensing technologies will increase monitoring and surveillance of the EEZ and also allow our government to assess environmental issues such as sea level rise, coastal erosion and other maritime related issues in order to take appropriate actions.

Along the California coast, the network of HF radar stations measures surface currents over a range of up to 200 km. I have previously discussed this program and its benefits for maritime domain awareness. Although the network was originally funded to track oil spills, and brings tremendous value for surveillance, it is also essential for search and rescue missions, marine navigation, and fisheries and water quality management that fall under the USCG's jurisdiction. The data is fed to operational watch standers within the National Weather Service, and at Coastguard Search and Rescue support centers. HF radar technology is also being developed for over-the-horizon ship tracking applications and is an emerging technology for maritime domain awareness. However, this opportunity will remain elusive under the current funding model for this national asset as the network is funded only at 50% operational capability of the $10M/year build out plan as identified in the U.S. IOOS National Surface Current Mapping Plan.

Dynamic Under Keel Clearance at Nation's Ports and Waterways
Sponsored by Andeavor, the nation's biggest oil refiner, the Under Keel Clearance Precision Navigation project at the Port of Long Beach highlights the importance of technology for public-private partnerships. Combined, the Ports of Los Angeles and Long Beach are the busiest port in the United States, and host a significant portion of California's economy. As vessels become more economically efficient, vessel length and draft have been increasing in size. During long-period wave activity, in which swells last over 12 seconds, conditions can cause a dangerous loss of draft (9.6 ft of draft for every degree of pitch) reducing the under-keel clearance to below safe levels. The objective of the Under Keel Clearance project is to minimize the offshore lightering, so that the deeper crude oil tankers can transit into the port. In partnership with NOAA which provides water depth, tides and wave forecast models, CDIP is providing high resolution wave observations and short term forecasts. To date, 32 additional deep draft tankers have been able to transit safely into the port. Every foot of additional draft equates to 40,000 barrels of crude oil valued at an approximately additional $2M in trade value. These efforts are critical for the economic, environmental and safety of marine operations.

Arctic Challenge: Monitoring and Promoting Safe Passage
The Arctic presents another set of challenges for ocean technology development. Arctic ice has begun to retreat, and is forecasted to continue doing so for the coming decades. This implies that what was learned about Arctic acoustics during the Cold War is now obsolete. One program tackling the change in the Arctic acoustic environments is the Canada Basin Acoustic Propagation Experiment (CANAPE). The overall objective of CANAPE is to determine the fundamental limits to the use of acoustic methods and signal processing imposed by ice and ocean processes in the new Arctic. Characterizing the changing operational environment in terms of ice coverage and sea state will be required before new infrastructure, including floating offshore platforms, can be designed to operate in this extreme environment. Partnerships developed with other federal ocean-minded agencies including the Navy, NOAA, National Science Foundation, and DARPA should be considered to leverage the respective investments of those agencies in improving U.S. sensing and forecasting capability for the Arctic.

Additionally, maritime commerce, including the world's navies, is expected to begin taking advantage of new Arctic shipping lanes during summer months. Commercial activity on the sea floor is also expected to grow. In response to changes in atmospheric and oceanographic conditions, large areas of the Arctic Ocean previously covered by pack ice and "insulated" from the wind and surface waves are now exposed. This change has lead to Arctic pack ice cover evolving into the Marginal Ice Zone. The emerging state of the Arctic Ocean features more fragmented thinner sea ice, stronger winds, ocean currents and waves. Modeling difficulties are compounded due to unique "local effects" including downslope winds, channeling and barrier jet, and shallow water storm surge. Lastly, the scarcity of in-situ data in the region limits situational awareness for maritime operations and numerical modeling.

CDIP will be deploying a new wave buoy offshore from the port of Nome in July 2018. Nome is the northernmost deep water port in Alaska that is called on by tankers, tugs and barges, passenger ships, government vessels, fishing and research vessels. Northern communities are heavily dependent on the safe operation of this port that is affected by weather and currents. In addition, a pilot program will assess the feasibility of expendable wave buoy technology in the harsh extremes

of the Arctic. These small wave buoys are easily deployed by hand and require no special training to deploy. The ease of deployment and relatively low cost afford the opportunity to seed areas with in-situ sensors to help close the data shortfall and advance Arctic Ocean wave modeling.

These technologies allow stakeholders and government entities a better understanding of ice cover in the Arctic as traffic in the area increases. This could help inform many of the Coast Guard's statutory missions including navigation, Cutter operations, defense readiness, and enforcement.

Conclusion

In closing, I would like to thank the Committee for the opportunity to testify on the role of ocean technologies and provide suggestions for the U.S. to leverage ongoing investments and use new maritime technologies to improve efficiency and mission performance. Scripps' scientists are leaders in research and operational use of maritime technologies and have a long history with national defense-related science, as and organization, we are privileged to be in a position to provide national service to this increasingly important topic. I believe that development of partnerships between USGS and other agencies (e.g. ONR, NAVY, NAVAIR, DARPA) for purposes of pursuing defense-related observational strategies and unmanned vehicle operations is very important.

Scripps recommends developing these partnerships with agencies that specialize in conducting maritime RDT&E (e.g. ONR) to provide low cost demonstrations of emerging technologies that can then be applied to full-scale operations, providing valuable feedback and business case requirements such as risk, cost, and manning requirements. Designing problem driven, modular applications for USCG missions will improve data reliability and performance as well as reduce complexity for watch standers. The use of data products from existing networks such as high frequency radar, wave buoys, and research vessels will significantly improve all aspects of USCG missions.

Additionally, leveraging joint operations such as Joint Harbor Operations Centers (JHOC) or the Joint Interagency Task Force (JIATF) will combine staffing, technologies, data services, and resources from multiple sources for improved response capabilities.

Dr. Eric Terrill, Director, Coastal Observing Research and Development Center
Scripps Institution of Oceanography, University of California San Diego
Responses to Questions for the Record issued by Hon. John Garamendi of California

Question: In your view, should Congress increase the Coast Guard's Research and Development budget, and if you agree, what would be a reasonable funding level?

Answer: Yes, Research and Development (RDT&E) funding should be commensurate with USCG current and future mission portfolios. Investment in RDT&E that will enhance operational safety, mission efficiency, and is embraced by the USCG as a priority. This will enhance overall readiness and mission success. USCG RDT&E needs are very similar to DOD/naval RDT&E requirements, and should be coordinated. Naval R&D has a track record of civilian continuity in supporting technical issues, yet this community is relatively untapped in supporting USCG.

Question: Do you agree that the economic impact of the Ocean Economy is likely to continue to grow, and that Blue Technologies offer new opportunities for growth and expansion within the larger U.S. ocean economy?

Answer: Yes. Sea lines of communication (SLOC), i.e. maritime routes between ports, used for trade, logistics and naval forces, underpins virtually all international commerce and our economy. A robust investment plan, identifying key business opportunities and investment priorities, which leverage Blue Technologies is a prudent course of action. Coastal populations only continue to grow, which is both a driver on Blue Tech, as well as a pressure on the marine environment.

Question: Would a national strategy be helpful in promoting and advancing Blue Technology innovation, or, is it best left to market forces to shape this outcome?

Answer: A collaborative roadmap/strategy is required to analyze, identify and scope out a common vision for the specific Blue Growth technology area, domain or value chain. This effort would also recognize unique national, security and scientific interests. Blue Economy extends much further than USCG, so difficult to comment if they should be the driver.

The maritime industry's ubiquitous presence around the world will always dominate SLOC. The collaborative development of an overarching strategy that calls on representatives from the Government, academia and the extended maritime industry (technology, shipping, ports) has the best chance of addressing salient issues for a national strategy.

Question: Are foreign competitors better positioned than U.S. firms to take advantage of the future global Blue Technology market? If so, what actions could be taken to improve the competitiveness of U.S. firms?

Dr. Eric Terrill, Director, Coastal Observing Research and Development Center
Scripps Institution of Oceanography, University of California San Diego
Responses to Questions for the Record issued by Hon. John Garamendi of California

Answer: I can only offer an observation that foreign entities appear to be better organized at this time. Our national interests are best protected by substantive collaborative engagement (as described above) followed by commensurate action, i.e. priority, policy, funding, etc.

Question: Are the Coast Guard's present arrangements or methods to interact with Blue Technology industries and firms sufficient to keep the Coast Guard abreast of the latest developments and innovations?

Answer: No, USCG R&D priority and funding do not match the current level of attention Blue Technology is receiving. A national priority tied to objectives and a budget is required. Independent, *ad hoc* engagement may prove ineffective. As indicated above, a partnership approach with the naval R&D enterprise is necessary for effective, efficient, and rapid technology insertion into USCG concepts of operation.

Question: How could the Coast Guard improve its interactions with the Blue Technology industry? Should the Coast Guard establish a new "Blue Technology Center of Excellence" as it has done for other issues?

Answer: There is an organizational vacuum regarding Blue Technology - who is the lead agency, what are the objectives, commensurate funding, etc.? A national priority tied to objectives and a budget is required before the USCG R&D can engage substantively with industry or academia. Centers of Excellence of have been tried before under DHS, and were not effective in establishing a pull for their activities.

Question: Assuming that you agree that the Coast Guard would benefit immediately and directly by investing more funding in Blue Tech research and development and in acquiring Blue Technology systems to supplement or enhance Coast Guard operations, what systems should be priorities for the Coast Guard to make R&D investments?

Answer: *Ad hoc* technical solutions addressing unvetted requirements is an unproductive solution. Formalized objectives based on a strategy are required to address shortfalls in a meaningful way. A vertically integrated system that establishes basic through applied R&D efforts, with demonstrations and technology testbeds is a suggested mechanism for stimulating technology insertion into the USCG. Office of Naval Research has a strong record in using a similar strategy for addressing emerging naval issues.

Question: Considering that most, if not virtually all, Blue Technology systems in some way rely on satellite telemetry and Global Positioning System signals, how much of a risk are cyber threats to Blue Technology systems? Are cyber threats slowing down market growth for Blue Technologies? Can we design and build these systems to be robust and resilient enough to fend off cyber-attacks?

Dr. Eric Terrill, Director, Coastal Observing Research and Development Center
Scripps Institution of Oceanography, University of California San Diego
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Answer: Internet based communications architecture is subject to compromise. Mitigations include a communications architecture which uses RF to local nodes for data relay, e.g. buoy nodes, unmanned surface vessels, unmanned aerial vehicles, etc. for coastal operations. All cybersystems have threats and vulnerabilities, but I don't believe are the rate limiting step in demonstrating Blue Technologies of value.

Question: Do you agree that a land-based back up signal for GPS, such as e-LORAN, is a necessary investment to ensure continuity and reliability across all forms of Blue Technologies?

Answer: Yes, if the data collection is viewed as a security, defense or economic interest meriting backup. However, I have not reviewed the trade-off study between GPS threats, methodologies to overcome (encryption) and the analog risks that exist for a land-based system.

Question: In the Arctic, what are the most pressing challenges that Blue Technologies could be applied to solve? Would it be helpful for Congress to authorize an Arctic Blue Technology Demonstration Program?

Answer: The national strategy for Blue Technology should address this question. As the Arctic opens, monitoring and in situ measurements are the best use of Blue Technologies, specifically for: prediction of new shipping lanes, environmental monitoring, shoreline change prediction, national territorial claims, SLOC, mineral resource exploration and exploitation, and atmospheric and oceanographic conditions.

Question: Integrated ocean observations appear to be critical in our understanding of the ocean environment and our interaction within that environment. What would it take to fund and build out the entire architecture for the Integrated Ocean Observation System?

Answer: The national Integrated Ocean Observation System primarily lacks directed funding. IOOS is the emerging strategy for Blue Technology, and government, Regional operations, and IOOS stakeholders should collaborate to endorse the existing studies that identify what the sensing shortfalls are, e.g. atmospheric, surface waves, thermohaline, geomorphologic, etc. and devise the appropriate sensors and sensing strategy (spacing, report timing, data ingest, assimilation, analysis, modeling). The

Question: Are there certain Blue Technologies that should be integrated fully into the infrastructure of the maritime transportation system to ensure safe maritime transportation and an efficient and reliable marine supply chain for the U.S. economy?

Answer: Collaboration with industry may help refine requirements. The International Convention for the Safety of Life at Sea (SOLAS)/International Maritime Organization may be

Dr. Eric Terrill, Director, Coastal Observing Research and Development Center
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useful contacts. Improved seaway predictions (waves, waterlevels, winds) are required to support the growth of very large containers ships from using existing port infrastructure.

Question: Does Blue Technology provide real potential for new job creation and diversification in the U.S. maritime workforce? Can Blue Technology attract more young people to look at career opportunities in maritime-related work, including traditional careers at sea or in ports and shipyard?

Answer: Yes, an industry exists today and will likely expand. STEM education programs can facilitate the technical educational foundation. Although the maritime-related field already is paid well, the nature of the work precludes many from pursing this a career.

Testimony of Michael B. Jones
President, The Maritime Alliance
Before the Coast Guard and Maritime Transportation Subcommittee
Of the House Transportation and Infrastructure Committee
At a hearing titled, "Blue Technologies: Use of New Maritime Technologies to Improve Efficiency and Mission Performance"
May 8, 2018 10 am

Chairman Hunter, Ranking Member Garamendi, Members of the Subcommittee, thank you for the opportunity to be here this morning to address this important topic. I am Founder and President of The Maritime Alliance (TMA) – a non-profit industry association founded in 2007 and based in San Diego. We are a leading voice for BlueTech nationally and internationally. Our Mission Statement is "Promoting Sustainable, Science-Based Ocean & Water Industries". Originally focused on San Diego – the largest U.S. BlueTech (ocean and water tech) cluster – we have a growing number of members in the U.S. and abroad. TMA has been a multi-year Strategic Partner with the US Dept. of Commerce and we are the organizer of the 1st ever US Maritime Technology Export Initiative working with small to medium-sized companies from across the country. In 2017, we helped form the BlueTech Cluster Alliance (BTCA) – the 1st international coalition of BlueTech clusters – with 9 leading BlueTech clusters from 7 countries.

I am here today to provide an overview of the Blue Economy and BlueTech in the U.S. and touch on select company technologies that could provide benefits to the U.S. Coast Guard in its diverse missions.

The State of the Blue Economy and BlueTech

The Blue Economy is enormous and growing rapidly. The 2016 OECD report "The Ocean Economy in 2030" predicted that it will double in size from $1.5 trillion in 2010 to over $3 trillion in 2030 while providing 40 million jobs globally. Special attention is given to emerging ocean-based industries. BlueTech companies are providing the innovative tools and services that permit these industries to develop. It is BlueTech that allows us to understand ocean problems (coral reef die-off, marine debris, mines, ocean chemistry changes, over-fishing, pollution, plastics, sunken vessels, temperature rise, tsunami generation and propagation, etc.)...and BlueTech is critical to develop solutions to these problems. The pace of BlueTech development is accelerating due to increased public awareness and attention regionally, nationally and internationally. Some countries and regions have focused heavily on the oceans including China, EU countries, Norway, and others. As an example, Norway adopted an Ocean Strategy in 2017 – the first industry strategy ever developed by Norway. In addition, the United Nations has proclaimed a Decade of Ocean Science for Sustainable Development from 2021-2030, which will provide a common framework to support the achievement of Sustainable Development Goal 14 on the ocean.

The State of the Industry

An increasing reliance on ocean resources (from aquaculture to deep sea mining to offshore wind energy) and the need to improve the way humans interact with the ocean (from more efficient vessel technology to broad environmental stewardship) will drive the Blue Economy and BlueTech. The user base is broadening as capabilities increase and prices decrease due to technological advancement, competition and economies-of-scale as market sectors grow. A sector like maritime robotics – platforms and sensors – is very strong in the U.S. due particularly to military, oil & gas and scientific demand, which sets the stage for large export sales – often 50% or greater. Another sector like ship building is supported domestically by the Jones Act and military procurement, but not as competitive internationally, while specialty areas can be quite strong such as high-efficiency turbines and technologies to defend against invasive species in ballast water or on hulls.

Some countries have focused heavily on new ship related technologies. Examples include autonomous vessels, e-navigation, wing sails on vessels, and more. Norway formulated an ambitious, national maritime strategy in 2015 to ensure a competitive regulatory framework, a competent maritime administration, a focus on environmentally friendly shipping, high-quality worker training, and to promote advanced R&D and rapid testing. It promotes synergy between industry sectors (aquaculture, fishing, oil & gas, shipbuilding, vessel automation, etc.) to develop maritime solutions.

The Potential for Blue Technologies to Support USCG Missions

The Maritime Alliance has over 90 members from across the U.S. and internationally – mostly leading edge BlueTech companies. In conjunction with BTCA cluster partners, we have access to thousands of companies in a growing number of countries. Innovative technologies in the U.S. can be exported as products and services...and innovative technologies abroad can be imported to develop Blue Jobs in the U.S. Following are select maritime issues that TMA-BlueTech member companies are addressing that may be of benefit to the Coast Guard as it seeks more efficient options to address its core missions.

Autonomy Software and Autonomous Vessels: Multiple TMA member companies are involved in autonomy in the air, on and under the water. Boston-based Sea Machines Robotics recently announced a contract with A.P. Moller-Maersk (Maersk), of Copenhagen, Denmark, to trial the world's first AI-Powered Situational Awareness system aboard a container ship by combining computer vision, Light Detection and Ranging (LiDAR) and perception software to augment and upgrade transit operations. San Diego-based Planck Aerosystems' drone intelligence improves real-time situational awareness via autonomous take off & landing from moving vehicles and vessels at sea, which has many uses in the ocean domain from fishing vessels to coastal mapping to spill detection / management to anti-piracy to special forces. Fugro's Houston-based U.S. headquarters is using data telemetry with remote command and control software to provide navigation, positioning and survey services to customers using shore-based command centers, eliminating the need for onboard surveyors (in some cases), while enhancing safety and efficiency.

Big Data (GIS Mapping Software, Location Platforms, Spatial Data Analytics & Weather Prediction): Enormous amounts of data are being collected by military, NGOs, NOAA, oil & gas, research/scientists, shipping, and other ocean stakeholders. Redlands, CA-based Esri – the world's leading GIS software mapping company – is helping unlock the potential of data to improve operational & business results. San Diego-based XST, Inc. provides Big Data consulting services including high-definition, hyper-local weather prediction for joint, maritime, expeditionary and special warfare operations.

Cybersecurity in the Maritime Domain: This is a rapidly developing concern. In the Port of Antwerp, hackers working with a drug-smuggling gang repeatedly breached digital tracking systems to locate containers holding large quantities of drugs and allowed gang drivers to collect containers ahead of scheduled collection times. A June 2017 cyberattack snarled shipping terminal operations worldwide and cost the shipping giant Maersk upwards of $300 million. Good cyber hygiene, training, and innovative technologies and services are needed to protect the logistics chain from ship to shore. Philadelphia-based Gnostech helps mitigate cybersecurity risks from sea to shore.

Likewise, jamming and spoofing of GPS is a major concern in maritime. In the last several years we have seen an increase in this activity with container ports idled, AIS safety systems disabled, and ships' positions being reported miles from their actual locations. GPS' vulnerability to disruption is a significant obstacle to safe use of remotely-operated and autonomous systems. One way to address this is by establishing an e-Loran system to complement and backup GPS.

Ocean Observation: The ocean enterprise—for-profit and not-for-profit organizations which support ocean measurement, observation and forecasting—is a critical component of maritime commerce and the Blue Economy. The Integrated Ocean Observing System (IOOS®) is the national-regional partnership that is focused on this important mission and enjoys wide industry support. **TMA** was co-author of "The Ocean Enterprise – A study of U.S. business activity in ocean measurement, observation, and forecasting", the first ever national-scale assessment of the size, scope, and value of the ocean enterprise, which was jointly published by IOOS and NOAA in February 2016. The study identified more than 400 firms in 36 states representing over $7 billion in annual revenue driving innovation across many industry sectors. These companies are important for the economy and critical for the maritime transportation industry.

Pollution Mitigation: San Diego-based Earthwise Sorbents is pioneering high performance, sustainable, recycled, and repurposed algae-based sorbents to clean-up oil and chemical spills on land and in water. These sorbents can absorb 9x their weight and are hydrophobic (i.e. do not leach back into water when saturated). Seattle-based Marine Construction Technologies has patented an innovative pile design that reduces noise pollution from impact pile driving by 80-90%. Less pile driving noise equals faster permitting, smaller zones of harassment/harm and fewer project delays thereby saving money and time while being a better ocean steward.

Port & Maritime Efficiency and Security: Durham, NC-based PortCall is a front-end platform for digital ports. It synchronizes vessel scheduling between ports, pilots, agents, and others. San Ramon, CA-based OceanManager develops maritime software to help ship owners and managers operate their vessels safely and efficiently and is now on over 850 vessels worldwide. Richmond, CA-based WAM-V produces a unique watercraft using suspension technology to radically improve seagoing capabilities so the ultra-light, easy-to-assemble/disassemble and crate vessel can perform in sea conditions where an ordinary boat cannot safely operate. It has been used in port security and ship inspection in various configurations including using it like a "mini-aircraft carrier" with quadcopter on the stabilized upper platform and tethered ROV that can work underwater.

Predictive Analytics: Seattle-based ioCurrents gathers real-time data from important assets on commercial vessels such as alarm panels, cargo, engines, generators, PLCs, etc. into a central database on a small, dedicated, low-cost computer to permit automatic onboard analysis with in-the-cloud availability and back-up. This allows operators to predict equipment failures thereby enhancing efficiency and safety of vessels. Failures at sea of even a small component can create high downstream cost that can result in a costly Coast Guard intervention to assist the vessel, downtime for the customer, and reporting requirements about the nature of the failure. By identifying failing assets before failure, the customer may order parts in advance for installation at the next port-of-call and downtime can be minimized.

Recommendations to facilitate U.S. Coast Guard assessment of Blue Technologies

The Coast Guard is a unique, internationally respected, multi-mission, maritime force. Its three major roles – maritime safety, maritime security, and maritime stewardship – span the maritime domain. **TMA** has interfaced with many fine USCG officers and staff and has been honored to have high-level speakers at our events. Following are some ideas we suggest that the Subcommittee consider to enhance USCG ability to identify, observe, test, and incorporate **BlueTech**:

- Increase travel funding to attend events where **BlueTech** is being shown / demonstrated;
- Increase funding to test and evaluate **BlueTech** products and services;
- Enhance the on-ramp to make it easier for innovative technology and services to be presented;
- Enhance the Innovation Council with regional meetings alongside shows to better find **BlueTech**, to avoid the cost/time to organize similar USCG events, and promote more contact with industry;

- Make regional "Tech Scouting" part of someone's role (e.g. Deputy Sector Commander);
- Establish a secondary Innovation center on the U.S. West Coast;
- Promote BlueTech collaboration and transfer to and from other U.S. government departments and agencies, operating in the marine domain (Navy and NOAA); and
- Promote BlueTech collaboration and transfer to and from other countries forces.

Conclusion

Thank you for the opportunity to testify today. We are grateful to the members of this Subcommittee for focusing on BlueTech and how it can help improve efficiency and mission performance. The Maritime Alliance stands ready to be a resource to this committee. I would be happy to answer any questions you have.

SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION
"BLUE TECHNOLOGIES: USE OF NEW MARITIME TECHNOLOGIES TO IMPROVE EFFICIENCY AND MISSION PERFORMANCE"
MAY 8, 2018

Responses from Michael B. Jones, President, The Maritime Alliance, to questions for the record from Hon. John Garamendi

WITNESS QUESTIONS FOR RECORD

Thank you for your thoughtful and concise statements and participation at the hearing. I have some general questions that I would like to ask each witness to get your reactions and to see if there is a consensus among witnesses.

- *In your view, should Congress increase the Coast Guard's Research and Development budget, and if you agree, what would be a reasonable funding level?*
- ANSWER: Yes. I don't know what current funding is, but it is not enough. We find that R&D folks don't even have the budget to fly from Oakland to San Diego to speak or attend events where they would see innovative BlueTech and interact with manufacturers.

- *Do you agree that the economic impact of the Ocean Economy is likely to continue to grow, and that Blue Technologies offer new opportunities for growth and expansion within the larger U.S. ocean economy?*
- ANSWER: Absolutely. "The Ocean Economy in 2030" report published by the OECD in 2016 expects the Ocean Economy to double from $1.5 trillion in 2010 to $3 trillion in 2030…and that ignores most BlueTech sectors since there is no way to gather that economic information today. The Blue Economy and BlueTech are major growth opportunities.

- *Would a national strategy be helpful in promoting and advancing Blue Technology innovation, or, is it best left to market forces to shape this outcome?*
  ANSWER: A national strategy would be incredibly valuable. The most important benefit would be a national recognition of the importance of the ocean and water economy, Blue Economy and BlueTech, which is largely invisible today. BlueTech allows us to find and do things underwater that were not feasible or economical 5-10 years ago. An "ocean race" has begun and governments around the world are focusing resources on it for economic and military reasons. Countries from China to France, Ireland, Norway, Portugal and the UK have or are developing national strategies. China has a major national effort to develop BlueTech clusters and a Blue Water navy. Norway announced its national ocean strategy in Spring 2017 – it's 1st ever industrial policy. U.S. companies will fall behind without the focused support that other countries are providing.

- *Are foreign competitors better positioned than U.S. firms to take advantage of the future global Blue Technology market? If so, what actions could be taken to improve the competitiveness of U.S. firms?*

ANSWER: Foreign competitors benefit from significant national and in the case of the European Union – multilateral – benefits not available to U.S. companies. These include: 1) strategies that organize government assets and staff to provide worldwide support for select industries (e.g. autonomous vessels, maritime robotics, and port development); 2) better Blue Economy and BlueTech economic analysis at national and regional levels; 3) financial and organizational support for organized, regional BlueTech clusters; 4) better research, R&D and export funding programs; 5) newer, better testing facilities; 6) better educational and technical training programs; 7) less likelihood of ITAR or EAR-like restrictions on dual usage technology; and 8) faster update of new technologies by government agencies. A suite of actions as part of a national strategy are needed to address this deficiency.

- *Are the Coast Guard's present arrangements or methods to interact with Blue Technology industries and firms sufficient to keep the Coast Guard abreast of the latest developments and innovations?*
  ANSWER: No. The Coast Guard does a good job with limited resources, but it could enhance its capabilities by having the time and resources to find, evaluate, test and field new innovative technologies.

- *How could the Coast Guard improve its interactions with the Blue Technology industry? Should the Coast Guard establish a new "Blue Technology Center of Excellence" as it has done for other issues?*
  ANSWER: The Coast Guard could promote a culture of innovation by making that part of its evaluation process from regional stations to senior command. CG stations are very operational and it is difficult to arrange for regional officers to look at innovative technologies, attend local events, or meet with companies. That means that everything is centralized. A BlueTech Center of Excellence would be very valuable, but it would need to have funding and staff for outreach, travel, and testing.

- *Assuming that you agree that the Coast Guard would benefit immediately and directly by investing more funding in Blue Tech research and development and in acquiring Blue Technology systems to supplement or enhance Coast Guard operations, what systems should be priorities for the Coast Guard to make R&D investments?*
  ANSWER: BlueTech improves constantly and the CG should opportunistically look for and test technology that help it full fulfill its three missions: Maritime safety, Maritime security, and Maritime stewardship. Some are obviously important like autonomy; cyber security / secure comms; fighting invasive species; robotics; and surveillance.

- *Considering that most, if not virtually all, Blue Technology systems in some way rely on satellite telemetry and Global Positioning System signals, how much of a risk are cyber threats to Blue Technology systems? Are cyber threats slowing down market growth for Blue Technologies? Can we design and build these systems to be robust and resilient enough to fend off cyber-attacks?*
  ANSWER: Cyber threats endanger all systems on land, in the air and at sea. Cyber at sea is different than on land because there are typically many different systems manufactured by different companies with crews (on the commercial shipping side) that are constantly changing. We can and must develop cyber hygiene processes and

systems that protect the commercial shipping system, but there are big risks …particularly when we are relying on an ever-smaller number of ports for the big container vessels. We should think strategically in addition to tactically.

- *Do you agree that a land-based back up signal for GPS, such as e-LORAN, is a necessary investment to ensure continuity and reliability across all forms of Blue Technologies?*
  ANSWER: Yes, absolutely. Both land-based and newer space-based systems that complement GPS are needed.

- *In the Arctic, what are the most pressing challenges that Blue Technologies could be applied to solve? Would it be helpful for Congress to authorize an Arctic Blue Technology Demonstration Program?*
  ANSWER: There is so much that we don't know about the ocean, but that is particularly true in the Arctic, which is opening up to research and exploitation as never before. I believe that Congress should authorize BlueTech Demonstration Programs in the arctic, but also in U.S. marine protected areas. We should promote these areas with expedited approval and funding to allow U.S. companies to test technologies to create "baseline data" in conjunction with academia, government and military organizations, which creates a win-win situation for academia, companies and government.

- *Integrated ocean observations appear to be critical in our understanding of the ocean environment and our interaction within that environment. What would it take to fund and build out the entire architecture for the Integrated Ocean Observation System?*
  ANSWER: The U.S. IOOS system is the "tip of the spear" in terms of gathering ocean data. Data are facts from which information is derived, and information needs to be put in context in order to make smart, informed decisions and promote economic, environmental and social benefits. IOOS and the Big Data projects at NOAA are extraordinarily valuable for the country to make informed decisions and should be promoted.

- *Are there certain Blue Technologies that should be integrated fully into the infrastructure of the maritime transportation system to ensure safe maritime transportation and an efficient and reliable marine supply chain for the U.S. economy?*
  ANSWER: There are many technologies that can help enhance the maritime transportation system. These include: 1) AI and autonomous vessels; 2) e-navigation; 3) real-time monitoring of vessel performance; 4) secure communications; 5) enhanced hydrographic monitoring; 6) technologies to enhance capabilities of medium-size ports and reduce dependence on a small number of mega-ports, and 7) research and later deployment of floating ports to improve efficiency while reducing Homeland Security and ocean rise risks.

- *Does Blue Technology provide real potential for new job creation and diversification in the U.S. maritime workforce? Can Blue Technology attract more young people to look at career opportunities in maritime-related work, including traditional careers at sea or in ports and shipyard?*

ANSWER: Absolutely. There are a growing number of opportunities in traditional, good paying Blue Economy and BlueTech jobs. For example, from a March 22, 2016 article in USNI News: "*By 2022, the United States will need "70,000 new people" for the nation's maritime fleet, but the Merchant Marine Academy at Kings Point, N.Y., and the six state maritime academies only graduate 900 per year and are at capacity, Paul Jaenichen Sr., the head of the U.S. Maritime Administration (MARAD), told the House Armed Services seapower and projection forces subcommittee on Tuesday.*" This need must be met by commercial companies that could be incented to expand. Many BlueTech companies are growing rapidly, but struggle to attract new talent. To a large extent that is because BlueTech has been largely invisible with little information available about it versus better understood industries like biotech, cleantech, and telecomm. This will change as it becomes better studied by the Bureau of Economic Analysis (Dept. of Commerce) and understood for the important sector that it is. The U.S. Departments of Education and Labor should focus on this national opportunity.

Michael B. Jones – President, **The Maritime Alliance**
Submitted: July 16, 2018

TESTIMONY OF
THOMAS S. CHANCE
CHIEF EXECTUTIVE OFFICER, ASV GLOBAL, LLC

BEFORE THE
U.S. HOUSE SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION

May 8, 2018

Mr. Chairman and distinguished members of the Committee, I am honored to testify today regarding the use of new maritime technologies to improve the efficiency and mission performance of the US Coast Guard. As CEO of ASV Global, the world's largest and most experienced unmanned surface vehicle company, I can speak as to where unmanned vessel technology is now and where it is going. However, before I do so, let me commend the work of the Coast Guard and this Subcommittee for its long history of outstanding service. The Coast Guard is saving lives, fighting crime, and defending our country on a daily basis, and the citizens of this country should never take this for granted.

Unmanned surface vehicles, or USVs, are unmanned boats. Like unmanned aerial vehicles (UAVs) and unmanned underwater vehicles (UUVs), unmanned surface vessels are revolutionizing the world we live in. Our company alone has delivered more than 100 USVs to military and commercial users across the globe. These USVs have ranged up to 40 feet in length, up to 1000 horsepower, and endurance in excess of 30 days. However, we currently have several inquiries, both commercial and military, for unmanned vessels in the 80' to 200' range with an endurance of up to three months. Leidos Corporation recently built a 132' USV, while the Norwegians and the Chinese are starting to build USVs up to 260' in length.

In addition to USVs that cannot accommodate personnel, ASV Global as well as others in the industry have built dozens of new optionally unmanned vessels. Optionally unmanned allows the asset to be deployed with a full crew onboard, a reduced crew, or no crew at all, and it allows the execution of unmanned missions as well as manned missions. Finally, ASV Global has upgraded several existing vessels to optionally unmanned. By upgrading to optionally unmanned, existing assets can experience the progression to unmanned without losing existing capabilities.

Unmanned vessels are being used for a variety of applications. In the military sphere, USV technology is being leveraged in mine hunting, mine sweeping and mine disposal, anti-submarine warfare, intelligence, surveillance, and reconnaissance (ISR), electronic warfare, and UAV

operations. From a commercial perspective, USVs are used for hydrographic and oceanographic surveys, underwater positioning and communications, marine mammal detection, oil spill dispersant deployment, oil spill boom towing, maritime firefighting, fish stock assessment, regional security, asset inspection, seismic operations, limited ROV operations, deployment of unmanned underwater vehicles, and deployment of aerial drones. Within the next few years, we will see larger USVs with longer endurance supporting much wider missions.

Just as driverless cars have a steering wheel and driver's seat, the current pragmatic approach to driverless vessels is to allow them to drive autonomously while remotely supervising their operation over a radio or satellite telemetry link. Situations requiring high speeds in high traffic areas are being avoided completely. At the same time, COLREG collision avoidance software continues to mature, so that remote supervision can eventually be phased over to full autonomous control.

Economics is the driving force towards the use of unmanned vessels. When you go from manned to unmanned ships, you don't need a galley and mess area. You don't need bunk rooms, hallways, heads, washing machines, dishwashers, freezers, stairways, workshops, a meeting room, or a full bridge. In a sense, an unmanned vessel is a hull with diesel tanks, engines, and a rack of computers and sensors. While I don't want to trivialize what is necessary for unmanned vessel operations, the capital cost of an unmanned vessel can be far less than that of its manned equivalent.

In addition to reduced capital costs, unmanned vessels can offer reduced daily operating costs as vessel personnel are condensed to those remotely supervising operations and those maintaining the unmanned vessels while in port. Maintenance of unmanned vessels is less than that of their manned counterpart as there is no personnel support equipment (such as refrigerators) to break. Finally, CONOPS such as offshore stationing can substantially reduce operational costs.

Unmanned vessels can be applied in two general ways. First, as force multipliers, where they are deployed and monitored from a manned mother ship. Second, they can work independent of other vessels, leaving port and transiting over the horizon to operate for weeks at a time while being monitored from a command center via satellite. Both methods are proven.

A byproduct of unmanned vessel technology is the bridge aid which would include COLREG collision avoidance software and the associated collision avoidance sensors. The bridge aid can be used to advise the ship's captain on navigation maneuvers, or, if necessary, it can be set to override manual systems to insure a collision is avoided.

Potential applications of unmanned vessel technology to the USCG are widespread. USVs can offer persistent maritime domain awareness, where unmanned, or optionally unmanned vessels, large and small, can remain on station for weeks at a time while providing intelligence, surveillance, and reconnaissance, as well as interception, and to a degree, interdiction. For example, ASV Global recently converted a 38' offshore patrol craft to optionally unmanned. That vessel will be able to patrol a region for up to two weeks at a time, as well as investigate suspect vessels.

With long endurance unmanned patrol craft stationed for long periods offshore, Coast Guard personnel at land-based command centers can dispatch deployed unmanned vessels to intercept and assess. VHF radios on the USVs can be accessed by the command centers via satellite relay to provide communications and two-way hailing options with intercepted vessels. Non-lethal weapons, such as prop / net entanglement systems can be deployed by USVs to stop suspect vessels until manned Coast Guard vessels can arrive and apprehend. Offshore stationed USVs can be used for drug vessel interdiction, illegal fishing interdiction, border protection, collision investigations, search and rescue, pollution incident investigations, and investigation of the numerous reported suspect vessels in distress.

Launches and rigid hull inflatable boats (RHIBs) installed on Fast Response Cutters, Offshore Patrol Cutters, and National Security Cutters can be upgraded to optionally unmanned giving the ship's officer the choice of dispatching these small boats with or without personnel.

Smaller USVs can be deployed from land or sea and programmed to replace missing channel markers and buoys by self-anchoring on location. Smaller USVs can also provide waterborne patrols of critical maritime infrastructure, harbor security, and swimmer detection.

Coast Guard vessels of all sizes are candidates for upgrades with collision avoidance bridge aids to mitigate maritime collisions. Future ship build programs should certainly consider fully unmanned, partially unmanned, and optionally unmanned ships.

These are just a few of the many applications of unmanned surface vessel technology that can be considered by the US Coast Guard. While additional appropriations are necessary for the Coast Guard to capitalize on unmanned technology, the economic and strategic advantages are likely to be overwhelmingly positive as they are with other unmanned technologies in the military and commercial sectors.

I would be happy to answer any questions you may have.

ASV unmanned marine systems

SUBJECT: BLUE TECHNOLOGIES: USE OF NEW MARITIME TECHNOLOGIES TO IMPROVE EFFICIENCY AND MISSION PERFORMANCE
WITNESS QUESTIONS AND ANSWERS FOR THE RECORD
U.S. HOUSE SUBCOMMITTEE ON COAST GUARD & MARITIME TRANSPORTATION
TESTIMONY DATE: May 8, 2018

WITNESS: THOMAS CHANCE, CEO, ASV GLOBAL (UNMANNED VESSEL TECHNOLOGY)

DATE: JUNE 19, 2018

1. **In your view, should Congress increase the Coast Guard's Research and Development budget, and if you agree, what would be a reasonable funding level?**

   Answer: It appears that the USCG's RDT&E budget was substantially reduced in the last couple of years from approximately $36m to $18m. I believe that the USCG's RDT&E budget should be restored to at least the $36m level with the additional funding being directed towards test and evaluation (T&E) and less towards (R&D). I believe the total amount of funds (even at $36m) are inadequate for USCG R&D, and that the private sector is more than willing to invest in the necessary IR&D to produce products to fill the needs of the USCG. In summary, funds should be increased for T&E, but the USCG does not, and frankly cannot, compete with the speed and efficiency of private sector's R&D efforts. The USCG should spend their scarce resources on evaluating technologies that can be used, or modified by the manufacturer and used, by the USCG in short order.

2. **Do you agree that the economic impact of the Ocean Economy is likely to continue to grow, and that Blue Technologies offer new opportunities for growth and expansion within the larger U.S. ocean economy?**

   Answer: Blue Technologies, including unmanned technology, have been, and will continue to grow and provide economic opportunities in both commercial and military sectors domestically as well as internationally.

3. **Would a national strategy be helpful in promoting and advancing Blue Technology innovation, or, is it best left to market forces to shape this outcome?**

   Answer: I would say that a national strategy forces a plan to be made now, and execution of that plan over time. Without a national strategy, plans can evolve over time with technology evolution, so that execution can capitalize on what makes sense in the present, as opposed to what made sense years earlier when the roadmap was established. So, unless a national strategy can attract national funding, I don't see it being beneficial.

ASV unmanned marine systems

4. **Are foreign competitors better positioned than U.S. firms to take advantage of the future global Blue Technology market? If so, what actions could be taken to improve the competitiveness of U.S. firms?**

   Answer: My firm, ASV Global, is building unmanned vessels in Europe as well as in the US. Foreign competitors, particularly in the Scandinavian countries, are heavily subsidized by their governments to capitalize on unmanned ship development opportunities. The funding is primarily used to position those companies to compete on an international platform with the development of large unmanned ships. The US government should subsidize US companies' development efforts before it is too late. In the case of the unmanned vessel business, it is an industry that will be in existence for many decades, if not for centuries. The US cannot afford to start off so far behind and miss this major industry development.

5. **Are the Coast Guard's present arrangements or methods to interact with Blue Technology industries and firms sufficient to keep the Coast Guard abreast of the latest developments and innovations?**

   Answer: I am not sure.

6. **How could the Coast Guard improve its interactions with the Blue Technology industry? Should the Coast Guard establish a new "Blue Technology Center of Excellence" as it has done for other issues?**

   Answer: A Blue Technology Center of Excellence means to me that the USCG will send money to some university who will 1) make up some stuff to study, and 2) spend a lot of its funds to insure it gets continued funding. In short, I would not establish another center of excellence.

7. **Assuming that you agree that the Coast Guard would benefit immediately and directly by investing more funding in Blue Tech research and development and in acquiring Blue Technology systems to supplement or enhance Coast Guard operations, what systems should be priorities for the Coast Guard to make R&D investments?**

   Answer: As stated, I would recommend that the USCG receive more funding to test and evaluate technology, not try to develop technology internally. I believe the USCG can hugely benefit from unmanned surface vehicle (USV) technology. Specific examples include the following:

   USVs can offer persistent maritime domain awareness, where unmanned, or minimally manned vessels, large and small, can remain on station for weeks at a time while providing intelligence, surveillance, and reconnaissance, as well as interception, and to a degree, interdiction. For example, ASV Global recently converted a 38' offshore patrol craft to optionally unmanned. That vessel will be able to patrol a region unmanned for up to two weeks at a time, as well as investigate suspect vessels, while being supervised from a USCG office via a satellite link.

ASV unmanned marine systems

With long endurance unmanned patrol craft stationed for long periods offshore, Coast Guard personnel at land-based command centers can dispatch deployed unmanned vessels to intercept and assess. VHF radios on the USVs can be accessed by the command centers via satellite relay to provide communications and two-way hailing options with intercepted vessels. Non-lethal weapons, such as prop / net entanglement systems can be deployed by USVs to stop suspect vessels until manned Coast Guard vessels can arrive and apprehend. Offshore stationed USVs can be used for drug vessel interdiction, illegal fishing interdiction, border protection, collision investigations, search and rescue, pollution incident investigations, and investigation of the numerous reported suspect vessels in distress.

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Smaller USVs can be deployed from land or sea and programmed to replace missing channel markers and buoys by self-anchoring on location. Smaller USVs can also provide waterborne patrols of critical maritime infrastructure, harbor security, and swimmer detection.

Coast Guard vessels of all sizes are candidates for upgrades with collision avoidance bridge aids to mitigate maritime collisions. Future ship build programs should certainly consider fully unmanned, partially unmanned, and optionally unmanned ships.

8. **Considering that most, if not virtually all, Blue Technology systems in some way rely on satellite telemetry and Global Positioning System signals, how much of a risk are cyber threats to Blue Technology systems? Are cyber threats slowing down market growth for Blue Technologies? Can we design and build these systems to be robust and resilient enough to fend off cyber-attacks?**

   Answer: Reliance on satellite telemetry and GPS in the marine environment is a vulnerability for many Blue Technologies. Radio spectrum jamming can impact sat comms and GPS, and spoofing has certainly proven to impact GPS. Land based supervision of maritime assets via satellite must provide for cyber-security, but that is much easier than dealing with jamming and spoofing. I don't think any of these threats are slowing Blue Technologies. I do think industry can fend off cyber-security issues, but jamming and spoofing is a federal government level problem.

9. **Do you agree that a land-based back up signal for GPS, such as e-LORAN, is a necessary investment to ensure continuity and reliability across all forms of Blue Technologies?**

   Answer: E-LORAN would be more accurate and robust than LORAN-C, but would largely suffer the same ionospheric issues inherent in any low frequency (100kHz) radio positioning system. That said, E-LORAN may be the best alternative to GPS. I would defer to those in

DARPA working on alternatives to GPS, as well as to tests that may have occurred with the development of E-LORAN in South Korea.

10. **In the Arctic, what are the most pressing challenges that Blue Technologies could be applied to solve? Would it be helpful for Congress to authorize an Arctic Blue Technology Demonstration Program?**

    Answer: I am not sure.

11. **Integrated ocean observations appear to be critical in our understanding of the ocean environment and our interaction within that environment. What would it take to fund and build out the entire architecture for the Integrated Ocean Observation System?**

    Answer: In 2012, the Jet Propulsion Laboratory estimated the cost of building out a global integrated ocean observing system at $55 billion dollars.

12. **Are there certain Blue Technologies that should be integrated fully into the infrastructure of the maritime transportation system to ensure safe maritime transportation and an efficient and reliable marine supply chain for the U.S. economy?**

    Answer: As mentioned in the last paragraph of #7 above, bridge aids that can warn and potentially adjust a ship's course in a COLREG compliant manner would likely dramatically reduce maritime collisions since most are due to human error.

13. **Does Blue Technology provide real potential for new job creation and diversification in the U.S. maritime workforce? Can Blue Technology attract more young people to look at career opportunities in maritime-related work, including traditional careers at sea or in ports and shipyard?**

    Answer: As the CEO of the world's leading unmanned surface vehicle company, ASV Global is centered in Blue Technology. Blue Technology is already creating thousands of high technology, high paying jobs. At the same time, it is offering efficiencies that will provide opportunities for growth in the short and long term. New unmanned vessel technology including unmanned ships, freighters, patrol vessels, and a wide variety of other ships will revolutionize the maritime industry. Yet as indicated in #4 above, foreign countries are investing heavily in the unmanned vessel industry, putting America's foreign competitors at a major global market advantage that will grow over time. Because of this, the US is already pretty much behind the eight ball.

IOSTIA
ADVANCING THE BUSINESS OF OCEAN TECHNOLOGY

Testimony

Christopher J. Coyle
Chief Strategy and Revenue Officer
Exocetus Autonomous Systems

Member
IOSTIA.com International Ocean Science and Technology Industry Association

Before the Congress of the United States
U.S. House of Representatives
U.S. House Committee on Transportation and Infrastructure
U.S. House Subcommittee on Coast Guard and Maritime Transportation

Congressional Hearing

Blue Technologies:
Use of New Maritime Technologies to Improve Efficiency and Mission Performance
2167 Rayburn House Office Building
Tuesday, May 08, 2018, 10:00am

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Good morning, my name is Christopher Coyle.

I want to thank the committee for giving me the opportunity to speak with you today about future blue technologies; a very exciting field.

Today, I am representing IOSTIA (IO-sha), the International Ocean Science and Technology Industry Association, which represents marine technology businesses and organizations that provide technology and services for sectors that sustainably and commercially utilize the oceans.

And, as an example of this hearing, IOSTIA also provides a unified public policy voice for those in our ocean technology space.

During the day, I am the Chief Strategy and Revenue Officer for Exocetus Autonomous Systems, of Wallingford, CT, which designs, manufacturers and services deep-sea robots, Autonomous Underwater Vehicles or AUVs.

I also lead the company's data and analytic initiative for the company's XPRIZE entry. In fact, Exocetus was named a semi-finalist in the Shell Ocean Discovery XPRIZE for mapping the ocean floor. We were one of only 19 teams selected from around world, out of 1,400 entrants, so we are extremely proud of this moon-shot award. In addition, Exocetus is a finalist in NOAA's prize for detecting chemical and biological signals underwater.

Our oceans cover 70% of the planet yet only 5% of the ocean floor has been mapped. We know more about the surface of the moon, than we know about what lies below the surface of our waters.

How is that possible?

Elon Musk, Jeff Bezos and Richard Branson have spent billions of dollars of their own wealth and billions more from investors to explore space. It's sexy and exciting. They have re-energized the planet's interest in outer space, intergalactic travel, and potential colonization of other planets. But it is entirely misguided.

The final frontier to be discovered is our oceans!

The next space race is our oceans!

Our planet depends on the access to healthy and plentiful oceans.

Our oceans and blue tech should be the focus; not space.

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As population growth climbs, as migration to concentrated coastal urban areas continues, as farmlands around the world shrink, as more and more people become dependent on fish protein, as seas play a more herculean role in carbon capture, oceans need to be today's focus for emerging technology, investments, and U.S. government attention.

And so blue tech is the critical technology to encourage as our children grow into adults and take on leadership roles.

This past week, I came across an article entitled **"Can the U.S. Navy Brave the Waves of Autonomous Warfare"**. I'll hand the article to your staff in case you'd like to include it in the hearing record.

The article's thesis is that AUVs offer great efficiency, mission range, and lower cost of capital than other more traditional naval means.

AUVs will prove to be cheaper to operate, put fewer seamen in harm's way, and therefore assume greater levels of risk.

AUVs are more expendable and can augment a fleet to do search and reconnaissance.

Last July, DARPA contracted BAE Systems to build small AUVs that can detect enemy subs. Today, AUVs are working on sea sensing and mine counter measure tasks.

By 2025, the Navy's AUV fleet will support undersea warfare by going into denied waters that are either too deep or too shallow for manned platforms.

AUVs will continue to provide greater benefit to the U.S. Coast Guard for port and waterway security, maintaining navigation, marine environmental protection, oil spill protection and response, marine pollution, fisheries, ocean shipping lanes, and in support of key components of the Coast Guard Authorization Act of 2017.

My company, Exocetus, is a quintessential example of a successful and sound U.S. government collaboration.

Exocetus was started with a $15M federal grant to develop its buoyance engine. This government investment resulted in three (3) patents on the engine design and one (1) on the retrieval system.

Today, we are proud to say that both the Navy and Coast Guard are presently using our AUVs.

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To me, the most exciting thing about AUVs are the sensors and the integration of all the emerging technologies such as cloud computing, artificial intelligence, machine learning, and blockchain to process the big data/analytics that will provide essential information and intelligence for our national defense, coastal erosion, port security, shipping lanes, laying fiber optic cables for communication, internet & media companies, and meteorological disturbances – to name just a few.

The future for blue technology is bright.

The million-dollar question is, are we going to seize this amazing opportunity and support and invest in brand new technologies, that will create high paying jobs of the future, or won't we? I can assure you that Russia and China will.

I am convinced that the blue economy, sparked by advances in blue tech, will be the next biggest revolution.

The best way to predict the future is to create it!

Thank you and I look forward to answering any of your questions.

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IOSTIA greatly appreciates the opportunity to respond to these thoughtful questions from Representative Garamendi. Because several of the questions presented are broad, we have sought input from our wider membership and affiliated organizations to ensure we provide concise and substantive responses. While many of the questions IOSTIA is well qualified to weigh-in on, we are not authorities in all subject areas. However, we have attempted to provide at least a general answer for each question. Organizations and individuals providing supporting information are recognized at the end of this document.

1. *In your view, should Congress increase the Coast Guard's Research and Development budget, and if you agree, what would be a reasonable funding level?*

   This question may be best asked of the Coast Guard as they are best positioned to elaborate on how increased funding would impact their adoption of novel technologies. However, in general we believe that increased funding coupled with strong and effective connections with industry and academia would benefit the Coast Guard, industry, and spur innovation across the various sectors of the blue economy.

2. *Do you agree that the economic impact of the Ocean Economy is likely to continue to grow, and that Blue Technologies offer new opportunities for growth and expansion within the larger U.S. ocean economy?*

   Yes, the various industry sectors that rely on ocean technologies are broad and among the most diverse in the U.S. economy. Essentially any human-marine interaction requires some form of technology to safely and efficiently realize economic benefit. The obvious industry sectors with the most potential include maritime/shipping, offshore & renewable energy, aquaculture, and seabed mining. Our ability to monitor, measure and map will continue to provide a significant competitive advantage for both business and national security. Technology applications impact wide areas including; our ability to discover and protect of cultural sites; the preservation of endangered species and habitats; the safe navigation; recreational activities; fishing; storm preparedness; weather modeling and prediction; documentation of climate change, and of course national security.

   Taking the first three alone, investment in technology can be focused in the four key areas:
   - Baseline audits, mapping measurement and documentation technology that includes a wide range of data collection, visualization and analysis tools
   - Power, hardware, extraction and cabling – this group are the enabling systems and support services to conduct economic activity like energy, rare earth mineral extraction, biopharma research and collection, etc.
   - Defense and homeland protection solutions utilizing manned, autonomous and unmanned systems to monitor the ocean and subsea environment
   - Communication systems

- Making Oil and gas exploration safer and more efficient. Cost-effective marine renewable energy development requires technology from site survey and assessment through installation and maintenance. The renewable technologies themselves have seen rapid technology advancements and spurring innovation can only lead to better and more affordable solutions.
- Finally, our need for rare earth elements and other mineable resources available at the bottom of the sea will only be accessible utilizing cost-effective ocean technologies

3. *Would a national strategy be helpful in promoting and advancing Blue Technology innovation, or, is it best left to market forces to shape this outcome?*

   Congress has proposed and debated legislation and the executive branch as offered and rescinded orders, but ultimately government has failed to pass an official act codifying a comprehensive national ocean strategy. There is strong interest within industry in seeing Congress address national security issues, economic development, and spurring the innovation required to maintain U.S. competitiveness. By challenging industry and offering a platform for strong public-private partnerships, the government could create an effective framework to achieve these outcomes. We have also observed a bias favoring academics within key organizations and committees and believe that in many cases more balanced representation from industry would potentially lead to better outcomes.

4. *Are foreign competitors better positioned than U.S. firms to take advantage of the future global Blue Technology market? If so, what actions could be taken to improve the competitiveness of U.S. firms?*

   Yes, for example the EU ocean industry is widely seen as more cohesive and better organized than its counterpart in the U.S. There are several reasons for this not the least of which are the challenges created by our geography (e.g. distance between key clusters of our industry). Our association also sees an opportunity arising from the start-up/emerging technology sector of the industry, but we do have concern about the availability and their access to grant monies. One suggestion might be for government to conduct a baseline audit of organizations with a history of government funding to evaluate the effectiveness and value of outcomes to ensure that taxpayer funded R&D is directed to the most promising and best executed programs.

5. *Are the Coast Guard's present arrangements or methods to interact with Blue Technology industries and firms sufficient to keep the Coast Guard abreast of the latest developments and innovations?*

   No. In our interactions with the Coast Guard we believe they realize this is a problem. They are attempting to establish stronger connections with industry through their innovation program. In fact, our organization will be sending a delegation of our members to demonstrate the latest

technologies to the Coast Guard. However, while they are keen to engage with organizations like ours, the outcome is uncertain. There appears to be a disconnect where innovation meets procurement.

6. *How could the Coast Guard improve its interactions with the Blue Technology industry? Should the Coast Guard establish a new "Blue Technology Center of Excellence" as it has done for other issues?*

   As mentioned in our previous answer, engagement with industry through hands-on demonstration of technology is one way our organization is responding to this need. There is certainly a role for industry associations to develop meaningful relationships with technology innovation centers, small business programs, and procurement officers. From the industry perspective, organizations like DARPA have been effective in stimulating innovation that ultimately leads to products and services that can strengthen mission effectiveness. However, at the same time it is critical to maintain strong industry engagement to order to be effective. Another idea of opportunity is to convene industry and government in regular occurring events. It is our understanding that the Coast Guard used to participate in a large annual technology exposition in the past called the U.S. Coast Guard Innovation Expo. We would strongly advocate for a Coast Guard/Non-Profit partnership to create a new annual event to serve the Coast Guard, Navy, and elements of Homeland Security that would focus exclusively on blue-technology.

7. *Assuming that you agree that the Coast Guard would benefit immediately and directly by investing more funding in Blue Tech research and development and in acquiring Blue Technology systems to supplement or enhance Coast Guard operations, what systems should be priorities for the Coast Guard to make R&D investments?*

   Again, IOSTIA may not be best equipped to answer this question. However, we generally feel that the systems and technology essential to the Coast Guard mission include 3D mapping of navigation hazards, gathering enhanced metocean data for safety and security. With better data, the Coast Guard can become more predictive and responsive in its monitoring. Beyond data, clearly investment more robust hardware and equipment such as unmanned systems and diver technologies, power and communication systems could have a positive impact on the Coast Guard mission.

8. *Considering that most, if not virtually all, Blue Technology systems in some way rely on satellite telemetry and Global Positioning System signals, how much of a risk are cyber threats to Blue Technology systems? Are cyber threats slowing down market growth for Blue Technologies? Can we design and build these systems to be robust and resilient enough to fend off cyber-attacks?*

   There are inherent and unavoidable cyber risks in blue technologies and security breaches are

inevitable. Keeping the perimeter locked is not always the most effective approach to preventing cyber risk. A key question to ask is what are the enabling solutions to keep operations safe and secure? Priority focus should be on identifying intrusion, monitor the intrusion, and protecting the system. A comprehensive answer to the question is beyond the scope of this Q&A, however IOSTIA would be pleased to organize a briefing to fully explore these challenges.

9. *Do you agree that a land-based back up signal for GPS, such as e-LORAN, is a necessary investment to ensure continuity and reliability across all forms of Blue Technologies?*

   The consensus view of IOSTIA members is no. We are not sure LORAN is relevant for back up DGPS now with new technology coming on carrier signals for for L1 –L5 GPS receivers. This means the cost of corrections are reduced greatly and the hardware to transmit these signals is much lower than current control networks and sub stations. The result in this means that devices that hold GNSS chip sets (iPhones / smart watches) will be able to position themselves with the new carrier signals embedded in the GPS or other orbital satellites and can provide decent sub meter location information. With this said, there may recreational uses to be considered.

10. *In the Arctic, what are the most pressing challenges that Blue Technologies could be applied to solve? Would it be helpful for Congress to authorize an Arctic Blue Technology Demonstration Program?*

    A thorough examination of the challenges to be addressed by blue technology regarding the Arctic, is well beyond the scope of this Q&A. However, the consensus view of our members is that the most pressing need is for hydrographic survey and mapping. The technologies needed exist and the funding of a demonstration program might lead to an incremental improvement in arctic specific technology applications, but not solve the immediate and most pressing need. Redirecting funding for additional survey work would likely be a better investment of tax payer money.

11. *Integrated ocean observations appear to be critical in our understanding of the ocean environment and our interaction within that environment. What would it take to fund and build out the entire architecture for the Integrated Ocean Observation System?*

    Up-to-date and reliable information about our oceans, coasts and Great Lakes is critical for safe and efficient transportation, for managing and planning to protect lives, properties and communities and for ensuring healthy, productive coastal environments. The US Integrated Ocean Observing System (IOOS) works with 17 Federal agencies and a national network of 11 coastal observing systems to efficiently and effective gather critical data and to make information available to all who need it.

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The entire architecture for the US Integrated Ocean Observation System was estimated in the Independent Cost Estimate (ICE) in 2012 at:
www.iooc.us/wp-content/uploads/2010/09/IOOS_Report_Volume_I_120503.pdf
www.iooc.us/wp-content/uploads/2010/09/IOOS_Report_Volume_II_120503.pdf

The Independent Cost Estimate projects $534M/year in non-federal costs to fully implement IOOS and $65M/year in central functions.

The IOOS Association has been working to communicate specific gap filling that would be easy to implement if additional resources were made available. To date, the campaign has focused on HF radars and gliders, a priority for both NOAA and Congress. The FY18 IOOS appropriations was $6.8M for National IOOS (i.e. central functions) and $35M for Regional IOOS Observations within the National Ocean Service budget of NOAA. The network is scalable, with each IOOS Region scoped at $4M per year in proposed work to NOAA, the program could easily increase capacity toward a more complete system. Additionally, IOOS includes R&D components in the Coastal and Ocean Modeling Testbed (NOAA's only coastal testbed), the Ocean Technology Transition project (competitive grant program to move emerging technologies into operations), and the Alliance for Coastal Technologies (sensor verification) funded at $5M in FY18.

A modest investment of additional funding to operate IOOS at $165M ($130M non federal and $15M for central functions) per year would enable meaningful implementation of IOOS observing, modeling, and data management to meet societal needs.

	FY18 funding	Tier 1 Increase	Sustained system
IOOS Regions (non federal)	$30M	$45M	$110M/year
IOOS R&D (non federal)	$5M	$10M	$20M
IOOS Central Functions	$6.8M	$10M	$15M
Total	$42.8M	$65M	$145M

U.S. IOOS has built plans to expand the network by filling gaps in observing capacity in every region. The future includes infusing new technologies and innovating to meet societal needs. As technologies evolve and develop, IOOS is positioned to innovate and refine observing systems while sustaining observing capacity to meet societal needs. By working in a community approach to develop and implement national plans.

IOOS and its partners have completed several national plans that identify needs. These national plans guide regional implementation. Each region is able to determine the most cost-effective mix of technologies that complement existing resources, to meet societal needs with national consistency.
National plans include:

National Surface Current Mapping Plan
Recommends increasing the number of radars to 351 to fill identified gaps. This would more than double the amount operating now (~150). The estimates cost is $23.2M per year.

National Waves Plan
The 2012 Update by USACOE and NOAA recommends a national backbone of 210 locations, 190 of which meet the directional wave accuracy and 60 sentinel stations. This would require 47 new wave observing locations ranging from the deep ocean to the estuaries and providing upgrades to 87 stations and adding 10 roving buoys for short term deployment to validate wave models that can be used for virtual wave gauges. Costs would be between $15M - $17M per year.

Toward a national glider network
The plan recommends adding 15 shallow water operations (suitable for the east coast) and 15 deep water lines suitable for the west coast where the continental break is closer, which will cost between $9-$12 M to capitalize and $6-8M to operate annually.

National Moorings Strategy
The 2017 Mooring Strategy priority recommendation is to add 56 ecosystem moorings that can measure a suite of chemical and biological parameters to the existing network of 754 moorings. These moorings would include sensors below the water surface to address the need for biological variables.

Ocean Technology Transition
A key component of the IOOS program of interest to IOSTIA is the Ocean Technology Transition project. "The Ocean Technology Transition project sponsors the transition of emerging marine observing technologies, for which there is an existing operational requirement and a demonstrated commitment to integration and use by the ocean

observing community, to operational mode. The primary objective of IOOS' OTT project is to reduce the "research to operations" transition period for ocean observing, product development, and data management technologies for the ocean, coastal and Great Lakes."

Federal Observing Systems

The ICE estimated that over 83% of the nation's ocean observing system is operated by the 17 IOOS Federal. These programs includes NASA satellite systems, Navy operations, stream gauges operated by USGS. The programs are funded by Congressional appropriation and, as such, are already planned and budgeted and are necessary for agencies to perform their missions.

IOOS integrates these existing investments and their related data streams to get more return on investment for the American public.

Note:
From the industry perspective there are ways to creatively increase operational ocean observing impacts without that level of spending. The architecture evaluated in the studies above is circa 2010 technology. Since then we have seen significant advancements in autonomous marine robots, commercial space technologies, cloud computing, and artificial intelligence/machine learning. There would be merit in an organized look at a new architecture based on modern technology that might deliver the significant benefits of ocean observing at lower cost and with increased societal and economic benefits.

12. *Are there certain Blue Technologies that should be integrated fully into the infrastructure of the maritime transportation system to ensure safe maritime transportation and an efficient and reliable marine supply chain for the U.S. economy?*

    Yes. From our perspective a good investment might be in subsea LIDAR scans for safety, security and hazards, proper monitoring of shipping lanes and ports and harbors, better continental shelf maps, marine/habitat monitoring, and tracking,

13. *Does Blue Technology provide real potential for new job creation and diversification in the U.S. maritime workforce? Can Blue Technology attract more young people to look at career opportunities in maritime-related work, including traditional careers at sea or in ports and shipyard?*

    Yes, it is clear from the success of STEM education programs in the ocean technology space stimulates interest in marine careers. The Marine Advance Technology Education organization

IOSTIA
ADVANCING THE BUSINESS OF OCEAN TECHNOLOGY

assesses workforce needs and works closely with high school and community colleges to prepare the next generation workforce for blue technology. It is just one successful example of an organization funded largely through grants that has been effective in tackling this problem, by reaching thousands of aspiring students. IOSTIA also sees opportunity for veterans and military (e.g. VR/AR technologies) as viable area to draw upon for talent. Organization's like Force Blue are working with veterans through their innovative programs.

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Written Statement of
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Before The
Subcommittee on Coast Guard and Maritime Transportation
Of the
Committee on Transportation and Infrastructure
U.S. House of Representatives

"Blue Technologies: Use of New Maritime Technologies to Improve Efficiency and Mission Performance"

May 8, 2018

Thank you Chairman Hunter, Ranking Member Garamendi, and Ranking Member DeFazio for the opportunity to testify today on the potential for maritime technology innovation to support efficiency and performance within the United States Coast Guard. I am pleased to provide testimony today on the role university-based research can play in providing the Coast Guard with information and tools that will help realize effective and efficient operations.

I am a Professor at the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University (OSU) and have been conducting research on the prediction and forecasting of ocean conditions for more than 20 years. As part of this effort, I have helped develop and test various wave and circulation prediction systems. I have also been involved with numerous large multi-agency observational campaigns to assess and improve the fidelity of ocean forecasts. These field campaigns have at times involved standard oceanographic instrumentation, and at other times have invoked innovative new technologies, including autonomous sensing. Finally, my work has explored ways in which forecast results can be presented and shared to make them most usable to stakeholders, including bar pilots, the fishing community, the National Weather Service, and the Coast Guard. Components of this work have involved basic research funding from various sources, including the National Science Foundation. Other more applied components have been funded by mission-oriented agencies, such as the Office of Naval Research, the Army Corps of Engineers, NOAA, and the Department of Energy. The presence of a multitude of funding agencies with interest in forecasting tools is encouraging, but it can also mean that close inter-agency coordination is imperative to holistically address challenges affecting coastal and at-sea operations.

Overview

This testimony summarizes current ocean state prediction and forecasting technologies and touches upon potential future enhancements that would increase the utility of the forecasts. The focus is on coastal regions and inlets where navigational planning and safety are of concern for the Coast Guard, along with recreational and commercial stakeholders. The discussion also covers recent efforts aimed at forecasting the potential for risk to the beachgoing public, including rip current and sneaker wave forecasts.

Ocean forecasting systems are enabled by a few key efforts. First, building forecasting models requires an understanding about the way in which the ocean works. Such an understanding can only be obtained through observations of the ocean-atmosphere system, and through careful analysis of the resulting data that enables us to hone in on the dominant natural relationships which can then be codified in the forecasting models. Such observations can be obtained as part of long-term ocean observing initiatives, but sometimes also require specialized innovative approaches to get at observations that are key pieces of the puzzle. Second, the accuracy of forecasting results can only be quantified if they are compared with observations of the conditions. Such data-model comparisons also guide further development and refinement of the forecasts. Finally, engaged educational activities involving the stakeholders and users of the forecasts point towards improvements in the forecasts while also training individuals to interpret forecast products as intended. This testimony will address all components of the system, including the forecast systems, the enabling observations, innovative data analysis, and the engaged educational programs required to enable the use of the forecasts for operational purposes.

Utilizing ocean wave and current forecasts for efficient navigational safety, safe passage, as well as search and rescue operations

Recent advances in predictive models now allow for detailed and high-resolution forecasts of ocean conditions. The forecasts include spatially well-resolved information about wave conditions and ocean currents in the open ocean, but also near navigational inlets where wave heights are strongly affected by tidal currents.

Although further development and testing is needed, wave forecasts in their current form can aid in several activities. For example, forecasts of ocean conditions in the open ocean can be used during search and rescue operations to narrow down the geographical area of interest. Forecasts near navigational inlets can be especially critical at challenging inlets where the transit through the river mouth can be treacherous. The Mouth of the Columbia River, bordering Oregon and Washington, often colloquially referred to as the "Graveyard of the Pacific," is one such example. The Coast Guard ships transit the bar during large wave events routinely. Further, the Coast Guard, collaboratively with other entities, makes decisions about bar closures that halt vessel traffic. Given that $24 billion of cargo moves on the Columbia River System annually, the cost of a bar closure to port operations and the local economy is significant.

One of the groups that play a role in bar closure decisions is the Columbia River Bar Pilots, a group of captains that are responsible for boarding every vessel that is crossing the bar and piloting it safely into or out of the inlet. The Bar Pilots make decisions about releasing vessels into river traffic from ports for transit across the bar. They require accurate forecast 10 hours in advance, because a tanker released from the upriver port of Portland requires hours to reach the river mouth. Once there, most of these tankers are too large to turn around, so the hazards of making the wrong decision are either a disaster on the bar or create the need to anchor a fully loaded ship in the river where there is a high likelihood that it will drag its anchor and go aground, given the strength of the waves (that routinely reach 30-35 ft) and strong currents (up to 4 knots).

For the last 5 years, the Columba River Bar Pilots have been utilizing OSU's wave forecasts over the area of the navigational inlet to inform their decision-making on navigational planning. The forecasts are specifically used for the computation of under-keel clearance values for vessels with a large draft, as well as for recommendations regarding the closure of the bar along with, perhaps more crucially, the timing for the opening of the bar. The forecasts have been developed at OSU and were funded by a variety of federal and local funding sources, including NOAA, the Office of Naval Research, and the Department of

Energy. We have worked extensively and iteratively with the Bar Pilots to create an interface for data retrieval that meets their needs and maximizes their ability to use the results. Efforts such as these are promising avenues to the translation of scientific discoveries to operational settings to increase safety and security.

Although much progress has been made recently to advance ocean forecasting technologies, there are several shortcomings that still need to be remedied to increase their fidelity and reliability. For example, advancements are needed to further our understanding of wave and ocean currents under challenging conditions, for example during storm conditions with large wave heights or for the prediction of rogue waves or sneaker waves. Accuracy is limited by our ability to codify natural processes related to wave processes (wave growth, swell dissipation, wave breaking processes, among others), circulation processes (presence and effect of gyres, data assimilative efforts, salinity temperature variability and ocean mixing), as well as wave-circulation interaction processes. Forecasts of conditions at tidal inlets can be especially challenging because waves are strongly affected by the tidal velocities that, at times, can cause localized wave amplification at the inlet mouth and can lead to navigational hazards. Forecast models need to accurately account for these interactions.

Further, following the weather forecast community, probabilistic forecasts are required for the most effective use of these forecasts. These are not currently commonplace and are not yet operational for ocean forecasting, but the trajectory of this work is promising. Improved understanding for real-time application would enable new technology-based tools to promote safe navigation, as well as safe and efficient search and rescue operations.

Sustained observations of the ocean

As mentioned above, the development of ocean forecasting models requires a fundamental understanding on how the ocean-atmosphere system works so that discovered relationships (for instance, between wind speed and wave growth) can be codified in the forecasting models. Such understanding requires the use and analysis of targeted observations to develop and test hypothesized relationships. Observations are also needed to validate produced forecasts and quantify the confidence in the produced forecasts extending into the future. Finally, real-time observations give us a sense of the actual current conditions and enable decision-making about near-term activities.

Ocean observations efforts benefit from recent improvements in innovative technologies and autonomous platforms (such as gliders, Unmanned Underwater Vehicles, and Autonomous Unmanned Vehicles) that are providing a look into the ocean that was not possible with previous technologies. While there is significant attention on the service support that UUVs or AUVs can provide, these autonomous platforms also allow us to sample continuously, at locations that would not be safe for sampling by humans. This is of particular value when working near unstable glaciers or during large wave conditions when ships cannot safely sample conditions. Advancements in the technology platforms to support ocean observations, and the application of observational data to inform real-time understanding and expectations of ocean conditions, are critical tools for improving safety and efficiency of ocean operations.

Innovative ways of employing new technologies to patrol the Arctic or other far parts of the EEZ.

Recent advances in unmanned vehicles have enabled excursions to areas that were previously not safely accessible. Of particular importance to the Coast Guard's Arctic mission objectives, OSU researchers are obtaining observations near glaciers that have been made possible by unmanned vehicles that can come close enough to the glaciers to obtain previously unobservable information. Such information should

prove crucial in the continued exploration of the Arctic that is becoming increasingly navigable but is associated with many unknowns.

Similarly, advancements in autonomous platforms are enabling new forecasting capabilities of wave heights. This has important potential applications for navigation, as well as protecting infrastructure and other critical assets. Obtaining wave height information during very large wave events is very challenging, and new rugged autonomous observing platforms are enabling such information and providing insight into conditions that remain challenging for forecast models, yet are important for operations.

As an example, wave height accuracy for nowcasts usually is around 10-15%, but new observations unearthed that model accuracies for very large waves (wave heights greater than 6 m) are sometimes well-predicted and at other times severely under-predicted, such as forecasting 5 m waves when the waves, in reality, reach 10 m, a potentially fatal mistake. Targeted new observations from autonomous platforms strategically deployed during large wave events have enabled us to pinpoint the environmental conditions during which the under-prediction occurred. This discovery enabled us to codify corrections to the forecast results (in this case, using machine learning technologies) to increase the forecast accuracy during large wave events.

Many further discoveries can be enabled by autonomous sensing, and there have been many advancements in autonomous vehicle technology. Gliders are now routinely being used to assess the state of the ocean. Some challenges still exist, especially near navigational inlets where salinity variations cause difficulties in sensing and in buoyancy regulation. As these challenges are being overcome, autonomous vehicles will enable further exploration and aid in patrolling functions.

Exploration through the Arctic or any other parts of the EEZ that is removed from civilization will also necessitate considerations of power requirements. This is where energy extraction from renewable sources may become important. Candidate sources are energy extraction from waves, or tidal currents, and technology development is currently underway. The last 20 years have seen surges in interest in wave energy extraction and development. The industry is still very young, and the considered technologies are varied and diverse. OSU is currently preparing to construct an off-shore grid-connected wave energy test facility with the Department of Energy that will allow technology developers to test and further develop their wave energy converter devices and is, therefore, poised to accelerate the development of wave energy technologies. Wave energy has promise for offering a viable source of energy in the future with potential importance to the Coast Guard's mission in the high seas and remote areas, such as the Arctic.

Promising emerging technologies geared towards identifying illegal activities at sea

Illegal, Unreported and Unregulated (IUU) activities at sea, their location and timing are challenging to assess and predict, yet such activities are of concern to the Coast Guard. Maritime IUU activities include illegal fishing and the trafficking of people, arms and narcotics. The key challenge is that vessels committing IUU activities turn off their GPS transponders and therefore "go dark." In fact, there are estimates that project that an an entire fleet of such vessels (a "dark fleet") is currently at work in the oceans. And although these vessels cannot be directly tracked, there is nonetheless a need to pinpoint their locations, or even provide short-term forecasts of their potential future positions.

New solutions for predicting IUU activity are currently emerging from academic research. They involve the field of mathematical geometry and information theory. These methods were originally developed to predict the behavior of complex systems such as the financial markets, but the principles apply in the context of IUU activities. More specifically, because the vessel traffic responds to the presence or absence

of other vessels in the area (whether they are visible or "dark"), observing the behavior of the visible fleet and any anomalous behavior within that system carries clues about movement of the dark fleet. Much like observations of visible celestial bodies can pinpoint the location of black holes, analysis of the movement of the visible fleet (with emerging mathematical methods) is showing promise in identifying the locations and movements of the dark fleet. These methods take advantage of the emerging science of "big data" and involve the melding and merging of disparate kinds of data sets to infer information of interest for national security. Further developments in this line of research could aid in developing more efficient and effective patrol strategies.

Engaged educational programs that train Coast Guard personnel

Close working relationships between the scientists who are developing products and the user base are crucial in assuring that the forecast products are tailored to the needs of the specific user. Our experience with wave forecasting products shows that the needs of the Bar Pilots are quite different from those of the tuna fishing industry. Hence, close engagement is needed during the development phase of the products. Further, translating scientific and technological advances to application by the Coast Guard will require specialized training of Coast Guard personnel. Both of these needs can be met with engaged educational activities that are designed to provide input and testing for forecast product interfaces while also helping personnel attain an intuitive understanding of the forecasts, their accuracy, and any potential shortfall. Note also, that these programs will benefit from close inter-disciplinary linkages between the Ocean Sciences and Engineering.

Such educational partnerships within graduate programs are already in place. For example, OSU houses a cross-disciplinary program in Nearshore Oceanography and Coastal Engineering and is engaging with Coast Guard students at the graduate education level. Further enhancing such programs with innovative hands-on curriculum that includes extensive experiential learning and focusses and tailors the education to the needs of the Coast Guard can enable them to engage fully with the latest blue technologies available to aid in the mission of the Coast Guard.

Summary

University researchers, myself included, are keen on seeing their discoveries translated to application and used to increase our safety and personal, national, and resource security. The scientific advances have been made possible through investments in science by various agencies. To that end, continued encouragement of inter-governmental collaboration in research and development among federal agencies invested in ocean sciences and operations is imperative to further advance knowledge for innovation in blue technologies. However, while the presence of multiple agencies with interest and investment in the research is encouraging, it also results in situations where the translation of the science to application can be difficult to fund. This is of particular concern with the constrained budget of the US Coast Guard mission, particularly for research and development. Nearshore ocean science is rapidly reaching a point of maturity so that numerous forecast technology products can be produced. With strategic investment in the Coast Guard for applied research and development and operations of direct importance to the Service capabilities, there is real potential to promote significant advancements in safety, efficiency and effectiveness of critical mission objectives.

In closing, I thank the Subcommittee for your efforts to consider the role of technology innovation and applications for efficiently and effectively advancing critical Coast Guard capabilities needed for the current and future mission objectives. I would be pleased to answer any questions.

Subcommittee on Coast Guard and Maritime Transportation

"Blue Technologies: Use of New Maritime Technologies to Improve Efficiency and Mission Performance"

May 8, 2018

Witness Questions for the Record from The Honorable John Garamendi

Responses from Dr. Tuba Ozkan-Haller, Ph.D.

Q: In your view, should Congress increase the Coast Guard's Research and Development budget, and if you agree, what would be a reasonable funding level?

A: Increased investment in the Coast Guard's Research and Development budget would help to further advance Service specific efforts to translate research and development, particularly related to blue technologies, to support Coast Guard mission capabilities and objectives. Many scientific advances and discoveries, including blue technologies, that have proven of value to Coast Guard capabilities have been made possible through federal investments in research and development through various federal agencies. First and foremost, I urge the Committee to pursue opportunities to provide continued legislative encouragement for inter-governmental collaboration in research and development among federal research agencies engaged in the ocean, including the Coast Guard. Further, in order to most efficiently and effectively ensure that federal investment in scientific advances can be translated to blue technologies of direct importance to Service mission objectives and capabilities, the Coast Guard would be well served by increased investment to support its own Service specific applied research and development objectives. Increased and strategic investment in the Coast Guard for applied research and development, including for blue technologies, would position the Service to more efficiently pursue and directly engage in efforts to translate innovation in such way that can effectively meet the specific needs of Coast Guard operations. Currently, limited resources to the Coast Guard to engage in applied research and innovation is a limitation for the development, application, and implementation of blue technologies in support of Service capabilities. Some of these R&D funds should be directed towards initiatives that enable the co-development of knowledge and related tools by the Coast Guard and Universities, further encouraging engaged research on the part of Universities with results that will directly feed into Coast Guard needs. While increased investment would be welcome and of value, I am not in position to propose a specific amount of increased investment that would be ideal.

Q: Are the Coast Guard's present arrangements or methods to interact with Blue Technology industries and firms sufficient to keep the Coast Guard abreast of the latest developments and innovations?

A: From the perspective of academia, I can convey positive experiences working with members of the Coast Guard to engage in efforts to develop and integrate Blue Technologies into Service capabilities. However, limited resources are an impediment to the optimization of these collaborations and the potential impacts. A close working relationship between a user and the scientists who are working to translate research to technology-based products is crucial to ensure that a developing technology or

system can be best tailored to meet the unique needs of the user. Increased resources to invest in and facilitate engagement between university researchers and the Coast Guard is needed to initiate and effectively advance the development of products that best meet specific capability objectives unique to the Coast Guard. Further, translating scientific and technological advances to application by the Coast Guard will require more specialized training of Coast Guard personnel. Increased resources can facilitate needed collaborations between the Coast Guard and research institutions for technology innovation as well as education and training needs. Such partnerships are already in place, but additional resources and commitment could streamline these relationships for efficient and effective outcomes.

Q: How could the Coast Guard improve its interactions with the Blue Technology industry? Should the Coast Guard establish a new "Blue Technology Center of Excellence" as it has done for other issues?

A: Investments in strategic partnerships between academia, industry, and federal agencies are proven to create pathways for nimble, collaborative, and timely research and development to meet specific mission or sector objectives. My experience suggests a Center of Expertise or Excellence that would be designed to facilitate partnerships between research universities and the Coast Guard for efficient applied research and innovation to support Service capabilities could enhance the Coast Guard's capacity to develop, test, and integrate blue technologies into the Service. Further, these Centers could also contribute to the education and training of students and current or future personnel on the cutting edge innovations.

A relevant example of a strategic partnership model in the ocean sciences arena is NOAA's Cooperative Institutes. NOAA's cooperative institutes are academic non-profit research institutions that demonstrate high levels of performance in conducting research that support's NOAA's mission goals and strategic plan. They collaborate with NOAA laboratories to create a strong, long-term collaboration between government and university researchers. Further, Cooperative Institutes also provide a mechanism for Administration sponsorship of students through fellowships, thus also helping to educate and train the next generation of workforce. Extramural research and education partnerships can provide timely and cost-efficient mechanisms for advancing cutting edge, translational research of direct importance to the Service.

Testimony of RADM Jonathan White, USN (Ret.)
President and CEO of the Consortium for Ocean Leadership
Before the House Committee on Transportation and Infrastructure,
Subcommittee on Coast Guard and Maritime Transportation
Blue Technologies: Use of New Maritime Technologies to Improve Efficiency and Mission Performance
8 May 2018

On behalf of the Consortium for Ocean Leadership (COL), I appreciate the opportunity to discuss marine technologies (blue tech) with subcommittee members today. COL represents the nation's leading ocean science, education, and technology institutions with the mission to shape the future of ocean sciences. Geosciences, broadly, and ocean science and technology, specifically, strengthen our homeland and national security, support a safe and efficient marine transportation system, underpin our economy, contribute to improved human health, and further the understanding of complex ocean and coastal processes behind the benefits from the sea upon which our nation relies. I consider this amalgamation of the securities that depend on robust ocean knowledge to ensure our safety and survival as "ocean security." Many overlaps exist between the missions of the United States Coast Guard (USCG) and the Department of Transportation's (DOT) Maritime Administration (MARAD) and ocean security. There are three important ideas you need to take away from my testimony today:

1. Ocean knowledge enables the USCG and MARAD in achieving their missions by enhancing maritime domain awareness (MDA).
2. Blue tech is vital to understanding the ocean.
3. Blue tech innovation and operation rely upon an advanced workforce educated and trained in ocean science, technology, engineering, and math (O-STEM).

This pyramid (mission success ← ocean knowledge ← blue tech ← O-STEM) is the best way to understand how marine technologies not only improve efficiencies and performance but are the very foundation that the USCG and MARAD rely on to meet their congressionally mandated missions. Since we live in a time of rapid technological advancements, it means this is not only true in the historic and present sense, but it is especially true in looking for the solutions of the future. Finally, it is critical to internalize that neither of the first two ideas can be actualized without the third – a strong STEM workforce.

I'm going to start by diving into my first two themes: understanding the ocean underpins the USCG and MARAD in achieving their missions by enhancing maritime domain awareness, and blue tech is vital to ocean security and enables understanding the ocean.

Ocean knowledge enables the USCG and MARAD in achieving their missions by enhancing MDA
As we have seen since the earliest history of our nation, superior knowledge of the ocean and the maritime environment has provided our armed forces with operational and tactical advantages that have ensured victory at sea and enabled the successful defense of our nation, sometimes against overwhelming odds. The late Admiral James D. Watkins, former Chief of Naval Operations, commented on several occasions that "Oceanography won the Cold War," in that our undersea ocean knowledge advantage provided us with operational and strategic advantages over the Soviet Union that deterred potential aggression. In numerous conflicts and other operations at sea, including search and rescue and law enforcement activities, superior ocean knowledge has ensured mission success, enhancing our safety, security, and prosperity.

It is paramount that the USCG maintains its strategic advantage in the maritime domain against threats to our security and safety. Threats such as terrorism, transnational crime, narcotrafficking, illegal fishing, etc., and the activities by rogue regimes (e.g., Iran, North Korea) threaten our nation and our homeland security in the maritime domain on many fronts. Ensuring robust and sustained funding for and prioritization of federal ocean science, technology, and education programs enable partnerships between federal ocean science agencies, research entities, industry, and federal maritime operating agencies and are key to ensuring the culture of innovation and initiative

that DHS and DOT need to meet their mission objectives today and tomorrow. Partnerships such as those enabled through the National Oceanographic Partnership Program (NOPP)—created by the National Oceanographic Partnership Act enrolled in the 1997 National Defense Authorization Act—do just that.

Ocean research and marine technology development provide the critical foundation to ensure continuity of our maritime knowledge superiority that generates advantage. Simply put, our ocean and coastal force must be able to win every potential armed conflict at sea, no matter how small or large. Thus, *we must be able to exploit our superior knowledge of the ocean environment to ensure "home field advantage" at both "home" and "away games."*

Blue tech is vital to understanding the ocean

The ocean contains 1.3 billion cubic kilometers of water. The deepest point in the ocean (the Challenger Deep in the Mariana Trench) is more than one mile deeper than Mount Everest is high (36,070 feet), and you can't just walk down it to explore it. How do we then explore the unreachable areas and understand what we can't see or feel (e.g., salinity, ocean processes)?

The answer lies in ocean science and technology, which have provided our nation with a knowledge advantage against myriad maritime threats. The Navy recently noted, through its Task Force Ocean process, that the nation's competitive advantage in understanding and exploiting the ocean environment has diminished and can only be re-established through investment in and prioritization of science and technology research across all federal ocean agencies.

The USCG, like the Navy, must maximize technological development to best understand the environment it is sending people into or to develop new ways to meet its mission objective without needing to place anyone physically into the environment and possibly in harm's way. A good example of this is the continued acceleration of autonomous undersea vehicles (AUV) and other ground-breaking undersea technology by the Navy and DOD. The impact of the ocean environment on these systems is even more pronounced than it was for the manned and tethered systems of the past.

Case Studies

IUU Fishing

Let's dig into what these two look like in the real world. Illegal, unregulated, and unreported (IUU) fishing is the term used when pirate fishers catch fish in violation of international agreements and treaties. IUU fishing is a global scourge with far-reaching consequences—like funding terrorist activities such as the 2004 al-Qaida bombings in Spain. There are clear links between IUU fishing and in addition to terrorism, other transnational criminal activity, specifically human, drug, and arms trafficking and smuggling.

The USCG supports enforcement of IUU fishing as part of its mission protecting our natural resources, endangered marine species, and marine sanctuaries—as well as in its mission to ensure our homeland security. The USCG detects and interdicts those fishing illegally in our waters (such as fishers from Mexico catching red snapper in the Gulf of Mexico), and enforces U.S. fishery and maritime laws. The Coast Guard estimates boats from Playa Bagdad (approximately five miles from our southern border) annually steal, at a minimum, $11 million worth of fish from U.S. waters. But their ability to stem the problem is limited - detecting them is hard, and catching them even harder, especially when ocean conditions are rough. What role can technology play, not only in spotting and catching illegal activity, but in anticipating it?

We should be gathering data from the sea every possible place – from the air, space, and water (boats, buoys, unmanned autonomous vehicles, gliders, and any other ocean sensor). Imagine what we could learn with an increase in ocean data. But don't stop there – now imagine if each ocean sensor, no matter its purpose, incorporated monitoring and surveillance technologies, allowing it to serve a secondary enforcement mission. This increased data collection would enhance MDA, informing scientists and law enforcement agents where the fish are so they can head off illegal fishing activity before it even begins – improving management, monitoring, and enforcement.

This will give them the needed head start to stop illicit activity before it even starts and will allow them to collect evidence necessary to prosecute the offenders. Blue tech – helping us understand the ocean, facilitating the USCG in its mission.

Arctic

For our second example, let's look north. We know the Arctic is dramatically changing, creating drastic increases in maritime access and activity. As it continues to do so, the U.S. (as an Arctic nation) has many economic opportunities but also faces significant challenges to the security, safety, and sustainability of this unique maritime domain, including our territory and our exclusive economic zone. Our capability and capacity to monitor and respond to threats and hazardous incidents in this dynamic and dangerous region is limited, difficult, and expensive, especially when considering ships and other manned craft and their associated support infrastructure. The implementation of unmanned and autonomous technology provides great promise for effectively monitoring and responding to threats and hazards while minimizing cost and risks to the safety of men and women at sea in the Arctic.

In summer 2017, the first ship to traverse the Arctic Northern Sea Route without assistance from ice-breaking vessels completed its journey. This transformational moment drives home both the opportunity and the imperative for the U.S. to ready itself for the new Arctic. The region is warming at twice the rate of the rest of the Earth with far-reaching consequences both for these polar residents and for those in the lower 48 states. On a global level, Arctic change will fundamentally alter climate, weather, and ecosystems in ways we do not yet understand, but we know there will be profound impacts on the world's economy and security. Rapid loss of sea ice and other changes will also bring new access to the area's natural resources, such as fossil fuels, minerals, and new fisheries, and this new access is already attracting international attention from industry and nations seeking new resources. Current Arctic observations are sparse and inadequate for enabling discovery or simulation of the processes underlying Arctic system change or to assess their environmental and economic impacts on the broader Earth system. One of the National Science Foundation (NSF)'s *Big Ideas* is the initiative *Navigating the New Arctic* (NAA), which would establish an observing network of mobile and fixed platforms and tools across this polar region to document these rapid biological, physical, chemical and social changes, leveraging participation by other federal agencies.

In 2013, the USCG released its Arctic Strategy to guide efforts in the area over the next decade. One of the strategy's key objectives is improving awareness, as "Coast Guard operations require precise and ongoing awareness of activities in the maritime domain. Maritime awareness in the Arctic is currently restricted due to limited surveillance, monitoring, and information system capabilities."

How do we improve those surveillance, monitoring, and information system capabilities? This is where autonomous vehicles come in. Whether we are discussing autonomous undersea vehicles (AUV) or autonomous surface vehicles (ASV), these robotic vehicles are programmable and can drive, drift, or glide (depending on their design) without humans crewing on board or even remote operators having to control them in real time. This technology can even go a step further when we incorporate artificial intelligence (AI). Imagine an AUV or ASV that can make decisions – changing its activities or course based on the environmental conditions it is encountering or data it has collected. It can make intelligent decisions, such as when, where, or how to sample and could even partake in cooperative activities and the transference of capabilities between vehicles.

Whether it's with AI or without, maritime autonomous vehicles let us explore regions of the Arctic that humans can't get to alone. For example, you may remember the AUV nicknamed "Boaty McBoatface." That AUV recently spent 51 hours under ice at the opposite pole, traveling 67 miles over the duration, reaching depths of more than half a mile below the sea surface. It even spent 20 hours beneath a section of ice shelf 550 meters (1804 feet) thick. AUVs and ASVs in their current state allow for new and increased data collection in regions previously inaccessible. Just imagine how much more they can do in the future as AI technologies are incorporated. Technology helps us learn about the Arctic, which in turn helps the USCG achieve its mission of safety, security, and stewardship in the region.

Natural Hazard Forecasting

For our last example, let's consider hazardous weather events such as hurricanes and other storms that increasingly threaten our homeland security, specifically the forecasting of their movement, intensity, and impact. Storm surge is often the greatest threat to life and property from coastal storms and hurricanes. Researchers are quantifying how future tropical storm surges may impact U.S. coastal properties, using past patterns of coastal sea-level change. From 1990 to 2008, population density increased by 32 percent in Gulf Coast coastal counties, 17 percent in Atlantic coastal counties, and 16 percent in Hawaii, according to the U.S. Census Bureau. In 2011, 45 percent of our nation's gross domestic product (GDP) was generated in the coastal shoreline counties along the ocean and Great Lakes. In 2016, the USCG saved 5,450 lives and responded to 16,298 events. Last year during Hurricane Harvey, they saved 4,322 lives in the Houston area alone. A storm surge of 23 feet has the ability to inundate 67 percent of interstate highways, 57 percent of arterial roads, almost half of all rail miles, 29 airports, and virtually all ports in the Gulf Coast area. U.S. ports are the heart of the nation's economy, delivering imports and transferring exports. When ports are closed due to storms and damage, the nation can lose $600 million to over $1 billion in a single day. Data and information on coastal property risk, emergency preparation, and storm forecasting are vital to owners, insurers, and the government.

How can blue tech matter in the face of natural disasters? The U.S. Navy is partnering with academia and the petroleum industry to launch ocean gliders in the Gulf of Mexico that autonomously and continually monitor seawater conditions (including heat content), aiding in improved hurricane *intensity* forecasting. These data and information enable more timely and informed preparation and emergency response by offshore industry as well as coastal communities and facilities. This type of blue tech partnership can be expanded to many other maritime safety and security applications through more robust implementation of NOPP by the federal ocean agencies.

Blue tech innovation and operation rely on an advanced workforce educated and trained in ocean STEM (O-STEM)

It is clear: without a substantial STEM education base, the USCG (not to mention the Navy, the rest of the government, industry, or anyone else) will be unable to depend on advancing technology developments to help meet their missions. Blue tech depends on O-STEM education; therefore, entities (this committee included) unused to supporting federal investments in STEM education must consider their futures as intrinsically linked to the success of STEM education programs. It's really rather simple: greater technology requires greater technicians, and that requires enhanced STEM education.

A secure, healthy, and prosperous maritime nation belongs to a society willing to evolve its workforce to meet the needs of a changing world. A diverse, well-educated, ocean-literate workforce provides the necessary base from which innovation grows. In 2016 it was estimated that STEM-based jobs account for up to 26 million U.S. jobs. From 2012 to 2022, there is a projected 12.5 percent growth of STEM jobs in the U.S. and a 14 percent projected increase in U.S. geoscience jobs in that same period. Coupled with the greying of America's geoscience workforce (47 percent of American geoscientists in the private sector and 43 percent in the federal government were over the age of 55 in 2016), it is clear we will experience major changes with our innovation workforce. Not only does the nation depend on the available pool of scientists, but it also needs those who will train the following generation and those whose work supports novel and emerging science solutions. A dynamic workforce moves our nation forward. From business professionals who can commercialize scientific advances to technicians who maintain observing infrastructure and employees trained in scientific principles, our future depends upon how we will meet these demographic and educational challenges.

Other nations are advancing rapidly with the hopes to overtake the U.S. as a scientific and technological superpower. Countries such as China, Singapore, and the United Kingdom are already identifying gaps and are making substantial federal investments in basic research, tech development, education programs, and workforce training. In January, NSF reported that for the first time China produced more scientific publications than the U.S. A metric for discovery and advancement, this is a concerning data point showing the U.S. is falling behind. Another can be found in venture capital investment—confidence in China's science and technology innovation was evident with $10.7 billion invested in the second quarter of 2017. While the value is lower than investments

in U.S. tech ($18.7 billion during the same time), it shows a dramatic increase from 2013 when less than $5 billion was invested for the entire year.

Like all technology, blue tech involves an interconnected web of disciplines and expertise, including software and hardware development; industrial manufacturing; computer programing and data management; and equipment calibration, maintenance, operation, and repairs. While innovation and design is an important part of technology there is an even larger demand for producing, operating, maintaining, and repairing the technology after it has been developed and commercialized. Skilled and knowledgeable technicians could be the limiting factor for blue tech growth, and capitalizing on two-year degree programs for blue collar O-STEM can help. Of the 26 million U.S. STEM jobs in 2016, 20-50 percent were seeking applicants with a two-year STEM degree (blue collar). Growing recognition for this demand is critical for decreasing the skill gap and building the O-STEM workforce. It is paramount that investments are made to establish this workforce and critical that industry skill needs are at the forefront when developing educational, apprenticeship, training, internship, and partnership programs to ensure the technologically advanced workforce being produced can be successfully deployed into the waiting jobs. A dynamic workforce of the future with abundant technicians knowledgeable in ocean science and trained in blue tech platforms is essential for maintaining current and allowing for future blue tech growth.

Formal and informal education programs train the technologically advanced future workforce and create an ocean-literate society. Currently the U.S. has over 400 college programs educating the next generation of ocean STEM workers. While the vast majority of these programs are four-year degrees, there is a distinct opportunity to expand two-year programs for the training of blue tech technicians. However, formal education is the not the only factor. Getting students and the community involved and interested in blue tech and ocean science is critical. Since most high school curricula don't include oceanography, informal educational programs, like the National Ocean Sciences Bowl (a program managed by COL) are increasingly important as a way to introduce students to, and get them excited, about a career in ocean science. The NOSB promotes collaboration, teamwork, ingenuity, critical thinking, and professional development, which are valuable skills for the O-STEM workforce. With some suggesting teenagers choose a major before even graduating high school, it's critical to engage these students and open their eyes to opportunities in this arena before it's too late. Additionally, immersive training, such as the Sea Grant College Program and NSF's I-Corps program, provide experiences and interactions with the professional world that cannot be obtained in the classroom. These programs and many other private internships, apprenticeships, and mentoring bridge academia, industry, government, and NGOs.

Increased O-STEM education and training will help ensure future USCG sailors have the requisite skills to embrace new and emerging blue tech to advance mission capabilities on par with (or ahead of) competing entities and threats. The 2012 transition of NOAA Corps officer training to the USCG Academy is an excellent example of how cross-agency and cross-community O-STEM education and training can be implemented to mutual benefit related to maritime safety, security, and economic growth. The Navy has extensive O-STEM education and training programs for officers, enlisted sailors, and government civilians that might also benefit the multi-service and multi-agency federal maritime work force.

Meeting the challenge of developing this foundation requires a substantial and focused effort on the education and training of the next generation of scientists to ensure we have the intellectual resources to take full advantage of new knowledge that will come from this investment in ocean sciences and technology, but it also needs those who will train the following generation and those whose work supports novel and emerging technology solutions. A dynamic workforce moves our nation forward. From business professionals who can commercialize scientific advances to technicians who maintain observing infrastructure and employees trained in scientific principles, our future depends upon how we will meet these demographic and educational challenges.

Conclusion

To successfully navigate a changing physical, chemical, and biological ocean while maintaining secure geopolitical boundaries and ensuring the safety and prosperity of those within them, the USCG and MARAD must regain their competitive advantage in knowing the ocean and coastal baseline conditions, changing conditions, forecasted conditions, vulnerabilities of maritime and coastal infrastructure, and the threatened

human population. The changing climate and ocean systems are altering when and where our maritime forces (uniformed and civilian) may be called to duty but also *how* they can respond. Rising sea levels increase coastal and near shore hazards; extreme weather could impact deployment, intelligence, surveillance, and safety capabilities; and the opening of previously inaccessible lands and waters will require additional response and rescue capacity. It is through the robust federal support of blue tech, STEM education, and collaborative partnerships across the federal family and with ocean science and technology institutions that the USCG and MARAD ensure that this will happen – ultimately enabling them to successfully fulfill their missions more effectively and efficiently.

Chairman Hunter, Ranking Member Garamendi, and members of the subcommittee, the ocean science and technology community appreciates the interest the subcommittee has in blue tech and I want to reiterate my themes:

1. Ocean knowledge enables the USCG and MARAD in achieving their missions by enhancing maritime domain awareness (MDA).
2. Blue tech is vital to understanding the ocean.
3. Blue tech innovation and operation rely upon an advanced workforce educated and trained in ocean science, technology, engineering, and math (O-STEM).

We urge the subcommittee to translate their interest in blue tech as a tool for USCG and MARAD to improve mission performance into prioritizing federal ocean science, technology, and education investment and programs. Working across committees and jurisdictions to do this is the way we ensure the U.S. maintains its superiority, security, success, and safety at sea. The ocean science, technology, and education community is well positioned to assist the subcommittee in addressing the role blue tech, ocean knowledge, and O-STEM can be more fully actualized for our nation's current and future maritime needs. We greatly appreciate your consideration and look forward to working with you to support the ocean science and technology innovation and education that enables our maritime superiority, coastal safety, economic prosperity, and ocean security.

RADM Jonathan White, U.S. Navy (Ret.), President and Chief Executive Officer,
Consortium for Ocean Leadership
Responses to questions for the record issued by Hon. John Garamendi of California

1. In your view, should Congress increase the Coast Guard's Research and Development budget, and if you agree, what would be a reasonable funding level.

While the Coast Guard budget it out of my purview, I always support increased investments in Research and Development budgets. I believe specific, additional funding for USCG-related science and technology R&D by the Office of Naval Research should be explored and strongly considered.

2. Do you agree that the economic impact of the Ocean Economy is likely to continue to grow, and that Blue Technologies offer new opportunities for growth and expansion within the larger U.S. ocean economy?

Yes. Between 2014 and 2015, the ocean economy's contribution to gross domestic product grew by 5.7 percent, which is twice as fast as the U.S. economy as a whole. Projections show the ocean economy doubling its contribution to global value from $1.5 trillion in 2010 to $3 trillion in 2030, and blue technologies are foundational to this continued strength and growth. Leveraging advancements in blue technologies to improve ocean monitoring is helping grow the ocean economy and support ocean industries.

3. Would a national strategy be helpful in promoting and advancing blue technology innovation, or is it best left to market forces to shape this outcome?

A national ocean strategy that addresses multiple agencies' concerns regarding ocean research and development, including blue technology innovation, would be helpful in promoting and advancing blue technology innovation. Using an existing vehicle, such as a reauthorization of the *National Oceanographic Partnership Program (NOPP) Act* (PL 104-201, 10 USC 7901-7903), would be an opportunity to require the development of such a strategy.

4. Are foreign competitors better positioned than U.S. firms to take advantage of the future global Blue Technology market? If so, what actions could be taken to improve the competitiveness of U.S. firms?

Yes. Other nations are advancing rapidly, including China. In the second quarter of 2017, China invested $10.7 billion in technology (a 214 percent increase from 2013). The U.S. is at a disadvantage because we do not have any established blue technology venture capital (VC) firms or specific VC funds.

Additionally, there are no robust efforts to track U.S. investment in blue technology, in part because tracking private investments in startup companies and technology is virtually impossible unless the transactions are made public or through specific industry-titled VC funds.

Experts in marine technology recognize the need to establish a designated fund to drive and monitor investments and are working towards this goal. In 2017, an important first step was taken by forming the global BlueTech Cluster Alliance coalition. By bringing blue technology companies together, investors can easily and efficiently see the breadth of technology available and how it works together. This partnership also allows for the ability to leverage expertise and share financial investments, including international money to foster growth in the maritime domain.

Congress can elevate the visibility of and investment in marine technologies through various legislative tools, including appropriations, authorizations, hearings, and briefings. This would be another opportunity where reauthorization of the *NOPP Act* would allow Congress to specifically task the NOPP agencies to analyze and track U.S. VC investments in blue technology.

RADM Jonathan White, U.S. Navy (Ret.), President and Chief Executive Officer,
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Responses to questions for the record issued by Hon. John Garamendi of California

5. Are the Coast Guard's present arrangements or methods to interact with Blue Technology industries and firms sufficient to keep the Coast Guard abreast of the latest developments and innovations?

As indicated during the hearing, no, there appear to be shortcomings. Reauthorization of the *NOPP Act* could address broader concerns among both agencies and industry and provides the opportunity for additional interactions with industry.

6. How could the Coast Guard improve its interactions with the Blue Technology industry? Should the Coast Guard establish a new "Blue Technology Center of Excellence" as it has done for other issues?

Collaboration and partnerships are key. The development of blue technology and a Center of Excellence should be done through partnerships with DOD, NOAA, and industry; these interactions can be improved by passing legislation encouraging or requiring these partnerships. An example of this is the *Commercial Engagement Through Ocean Technology Act of 2018* (H.R. 5196/S. 2511), which directs NOAA to coordinate with the Navy, other federal agencies, industry, and the academic sector when developing unmanned maritime technology. Through this partnership, agencies can leverage expertise and resources (e.g., test and training ranges, laboratories) to develop technology that meets multiple needs and has a range of applications.

7. Assuming that you agree that the Coast Guard would benefit immediately and directly by investing more funding in Blue Tech research and development and in acquiring Blue Technology systems to supplement or enhance Coast Guard operations, what systems should be priorities for the Coast Guard to make R&D investments?

Autonomous systems, such as autonomous undersea vehicles (AUVs) and autonomous surface vehicles (ASVs), are one clear choice for R&D investments. These systems, and others like them that monitor the ocean and its features, could even serve a dual purpose by incorporating monitoring and surveillance technologies, augmenting the Coast Guard's surveillance and reconnaissance capabilities. This would have countless benefits, including helping the Coast Guard more efficiently identify, intercept, and even collect evidence to build cases against illegal, unreported, and unregulated (IUU) fishing activities.

In addition to gathering data from ocean-based technologies, the Coast Guard should also explore investing in R&D for technologies that will improve ocean monitoring from space. CubeSats, for instance, are miniaturized, low-cost satellites often used for research and monitoring of Earth systems. The use of CubeSats to monitor in-situ ocean systems could further supplement the Coast Guard's ability to gather ocean observations, especially in the Arctic, where remote observations are important due to the region's inaccessibility.

8. Considering that most, if not virtually all, Blue Technology systems in some way rely on satellite telemetry and Global Positioning System signals, how much of a risk are cyber threats to Blue Technology systems? Are cyber threats slowing down market growth for Blue Technologies? Can we design and build these systems to be robust and resilient enough to fend off cyber-attacks?

There are cyber threats to all GPS technology, including blue technology. In my former role as Navigator of the Navy, I worked closely on information warfare missions of the Navy, which were classified. Cyber warfare is being explored and addressed by DOD, in conjunction with DHS and other agencies, to

minimize the threat and ensure we have the necessary resilience to fend off cyber attacks. Innovations from these initiatives will benefit blue technology, but the work is already being done.

9. Do you agree that a land-based back up signal for GPS, such as e-LORAN, is a necessary investment to ensure continuity and reliability across all forms of Blue Technologies?

Yes. Alternatives to GPS, including land-based systems, are important and are being considered by DOD, DHS, and other classified entities. This should be closely monitored by Congress.

10. In the Arctic, what are the most pressing challenges that Blue Technologies could be applied to solve? Would it be helpful for Congress to authorize an Arctic Blue Technology Demonstration Program?

Maritime domain awareness in the Arctic is the most pressing challenge blue technology can address, particularly as the Arctic landscape changes. Improving surveillance, monitoring, and information system capabilities through blue technologies — such as autonomous surface or underwater vehicles — will enhance the Coast Guard's ability to fulfill its mission of safety, security, and stewardship in the region. Better Arctic observations, as provided by blue technologies, will enable the U.S. to monitor and respond to threats and hazards to the area in a timely, safe, and cost-effective manner.

Authorizing an Arctic Blue Technology Demonstration Program would certainly support the work being done on blue technologies. Additionally, the Coast Guard should strengthen its existing collaborations with the Navy through the Ice Exercise (ICEX) program and other similar joint efforts to facilitate the sharing of information, strategies, and best practices related to blue technologies.

11. Integrated ocean observations appear to be critical in our understanding of the ocean environment and our interaction within that environment. What would it take to fund and build out the entire architecture for the Integrated Ocean Observation System?

Yes, integrated ocean observations are critical to our understanding of the ocean environment, and IOOS is a critical piece of that. To better answer this question, it should first be posed to federal agencies so they can provide a full answer of their prioritized needs from IOOS. This is a perfect example of why we have NOPP designated as a leadership authority and why reauthorizing the *NOPP Act* would improve our understanding of our ocean environment.

12. Are there certain Blue Technologies that should be integrated fully into the infrastructure of the maritime transportation system to ensure safe maritime transportation and an efficient and reliable marine supply chain for the U.S. economy?

The finer details of this question are beyond my purview and expertise, but in general, the adoption of more autonomous, in-situ, and spaced-based blue technologies to monitor the ocean will reduce uncertainties in ocean observations and by extension strengthen maritime transportation infrastructure. These will be especially important for transportation in the Arctic, where the area's remote and dynamic nature poses challenges to marine transportation.

RADM Jonathan White, U.S. Navy (Ret.), President and Chief Executive Officer,
Consortium for Ocean Leadership
Responses to questions for the record issued by Hon. John Garamendi of California

13. Does Blue Technology provide real potential for new job creation and diversification in the U.S. maritime workforce? Can Blue Technology attract more young people to look at career opportunities in maritime-related work, including traditional careers at sea or in ports and shipyards?

With the anticipated grown of the blue economy, I expect there will be new jobs and that blue technology, as a career option, will attract more people. As we look at the changing ocean and the rapid variations in maritime activities associated with information technology and automation, the requisite skills must be closely examined and applied to education and training efforts within the U.S. federal agencies (including the Department of Education) and should identify and highlight these efforts, in concert with previous and ongoing efforts by the National Academy of Sciences and under the guidance of a program such as NOPP.

Additionally, to ensure students are introduced to blue technologies in time to put them on the appropriate career path, I encourage you to support programs such as the National Ocean Sciences Bowl (NOSB). Since most high schools don't have oceanography in their curricula, the majority of high schoolers can only learn about ocean science and technology-related careers through informal education programs, such as the NOSB, which has had a demonstrated impact on career choices.

Letter for the Record
Brian Wynne, President and CEO
Association for Unmanned Vehicle Systems International
House Coast Guard & Maritime Transportation Subcommittee
Blue Technologies: Use of New Maritime Technologies to Improve Efficiency and Mission Performance

Dear Chairman Duncan and Ranking Member Garamendi:

The Association for Unmanned Vehicle Systems International (AUVSI) is pleased to provide input to you regarding the hearing the subcommittee held on May 8, 2018 concerning Blue Technologies. AUVSI is the world's largest non-profit organization devoted exclusively to advancing the unmanned systems and robotics community. AUVSI has been the voice of unmanned systems for nearly 50 years. We represent corporations and professionals from more than 60 countries involved in business, government and education. AUVSI members work in the defense, civil and commercial markets. AUVSI and its member companies strongly support the United States Coast Guard's (USCG) mission and the development of new maritime technologies that will improve efficiency and mission performance to enhance the security of our nation.

Both the defense and commercial unmanned maritime systems (UMS) markets have experienced substantial growth in the last decade. Maritime stakeholders from large shipping companies to significant ports are investing in a future where unmanned technology improves operations. Platforms such as Unmanned Underwater Vehicles (UUVs), Unmanned Surface Vehicles (USVs), Unmanned Ground Vehicles (UGVs), and Unmanned Aircraft Systems (UAS) are frequently employed to promote safety and assist the warfighter. The implementation of unmanned technologies is critical to the United States' ability to remain the predominant global military force, as well as securing our shores.

AUVSI maintains a significant presence in the maritime domain. Our organization annually hosts the Unmanned Systems Defense. Protection. Security. (USDPS) This conference brings together government decisionmakers for networking and presentations. At this year's USDPS there were UMS-focused presentations by Assistant Secretary of Defense for Research and Engineering, Mary Miller; Acting Under Secretary of Commerce for Oceans and Atmosphere for NOAA, Rear Adm. Tim Gallaudet; Acting Deputy Director, Tactical Technology, DARPA, Jean-Charles Ledé.

Additionally, AUVSI organized a member-driven UMS working group primarily focused on the International Regulations for Preventing Collisions at Sea (COLREGs). The group's recommendations concerning UMS best practices were submitted to the USCG in 2016.

More recently, AUVSI hosted several meetings with the office of the Deputy Assistant Secretary of the Navy for Unmanned Systems. They provided a forum for the Navy and industry representatives to discuss operational needs, acquisition processes and the future of UMS. This group is now a standing UMS Advocacy Committee with members from every sector of the UMS industry. The UMS Advocacy Committee aims to maintain response to military and commercial maritime needs, facilitate maritime growth, and provide a unified industry voice. The committee and its members are well positioned to assist the USCG in its efforts to increase the integration of blue technologies into broad mission sets.

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The USCG's three pillars of maritime safety, security and stewardship are best supported through collaboration and partnership with UMS industry stakeholders. AUVSI consistently aims to bridge the reoccurring gap between solution providers and solution enablers. AUVSI members can be innovative and significant resources for the USCG Research, Development, Test, and Evaluation (RDT&E) program by providing forums to streamline communication and discuss operational needs.

AUVSI also works with its foundation RoboNation, whose mission is to provide a pathway of hands-on educational experiences that empower students to find innovative robotics solutions to global challenges. RoboNation focuses on STEM and Kindergarten to workforce programs that help students experience robotics at a young age. They host several annual events and competitions, including the International SeaPerch Challenge, International Ground Vehicle Competition (IGVC), Student Unmanned Aerial Systems (SUAS), International Aerial Robotics Competition (IARC), RoboBoat, RoboSub and Maritime RobotX, which has over 3,000 participants. RoboNation also has programs that assist underprivileged students with robotics through Kits for Kids and has granted STEM kits through funding from the Office of Naval Research.

On behalf of AUVSI members, particularly those involved in the UMS industry, we again express our appreciation for the opportunity to provide these comments. AUVSI has maintained an excellent working relationship with the USCG and the Navigation Safety Advisory Council (NAVSAC), and looks forward to continuing to support the USCG in its approach to blue technologies. Please contact me whenever AUVSI can be of assistance.

Sincerely,

Brian P. Wynne
President and CEO

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